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THE GEOLOGY OF THE HUANCAVELICA MERCURY DISTRICT

THE JOHNS HOPKINS UNIVERSITY
STUDIES IN GEOLOGY

No. 2

EDITED BY
EDWARD BENNETT MATHEWS

THE GEOLOGY AND PALEONTOLOGY OF THE HUANCAVELICA MERCURY DISTRICT

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By Edward W. Berry and Joseph T. Singewald, Jr.

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THE GEOLOGY AND PALEONTOLOGY OF THE HUANCAVELICA MERCURY DISTRICT*

WITH NOTES ON OTHER MERCURY OCCURRENCES IN PERU.

I. THE DISTRIBUTION OF MERCURY IN PERU.

Mercury ore is of widespread occurrence in Peru, being found along the Andes from Cuzco and Puno in the south to the northern departments. Both Raimondi and Becker cite numerous occurrences extending from 6 to 15 degrees south latitude. These are from north to south; Chachapoyas in Amazonas; the Santa Apolonia Mountains near Cajamarca; Vuldivui near Pataz in Libertad; Huachrachuco, Paccha, and Chonta in Huánuco in Ancachs; Antocallana on Lake Lauricocha at Quipan near Cerro de Pasco, Punabamba, and Yauli in Junín; Huancavelica in Huancavelica; Chuschi in the Province of Cangallo in Ayacucho; and Ayaviri in Puno. Arana says that specimens of mercury are encountered in the district of Paucartambo (Paucarbamba) in the Province of Tayacaja, in Huancavelica; and Crosnier describes an occurrenee at Pucará in the Morococha region, which is, therefore, not far from Punabamba.

The Huancavelica district is the only district that has furnished a large output. Chonta is the only other at which there has been even a regular production. Most of the other occurrences have yielded hardly more than specimens, and in many instances absolutely nothing is known concerning the nature of the occurrence. The wide distribution of mercury minerals in Peru was known in Colonial time, and it was popularly believed that Peru had many deposits of the magnitude of Huancavelica which lay idle and were not developed because of royal decree. However, in the latter part of the Colonial period, when the Huancavelica production failed to meet the demand for mercury, a diligent search was made for other deposits and attempts made to develop new mines. Chonta was the only locality that yielded even a small output. Hence the probability is against the existence of any other mercury deposits of similar magnitude in Peru.

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* George Huntington Williams Memorial Publication No. II.

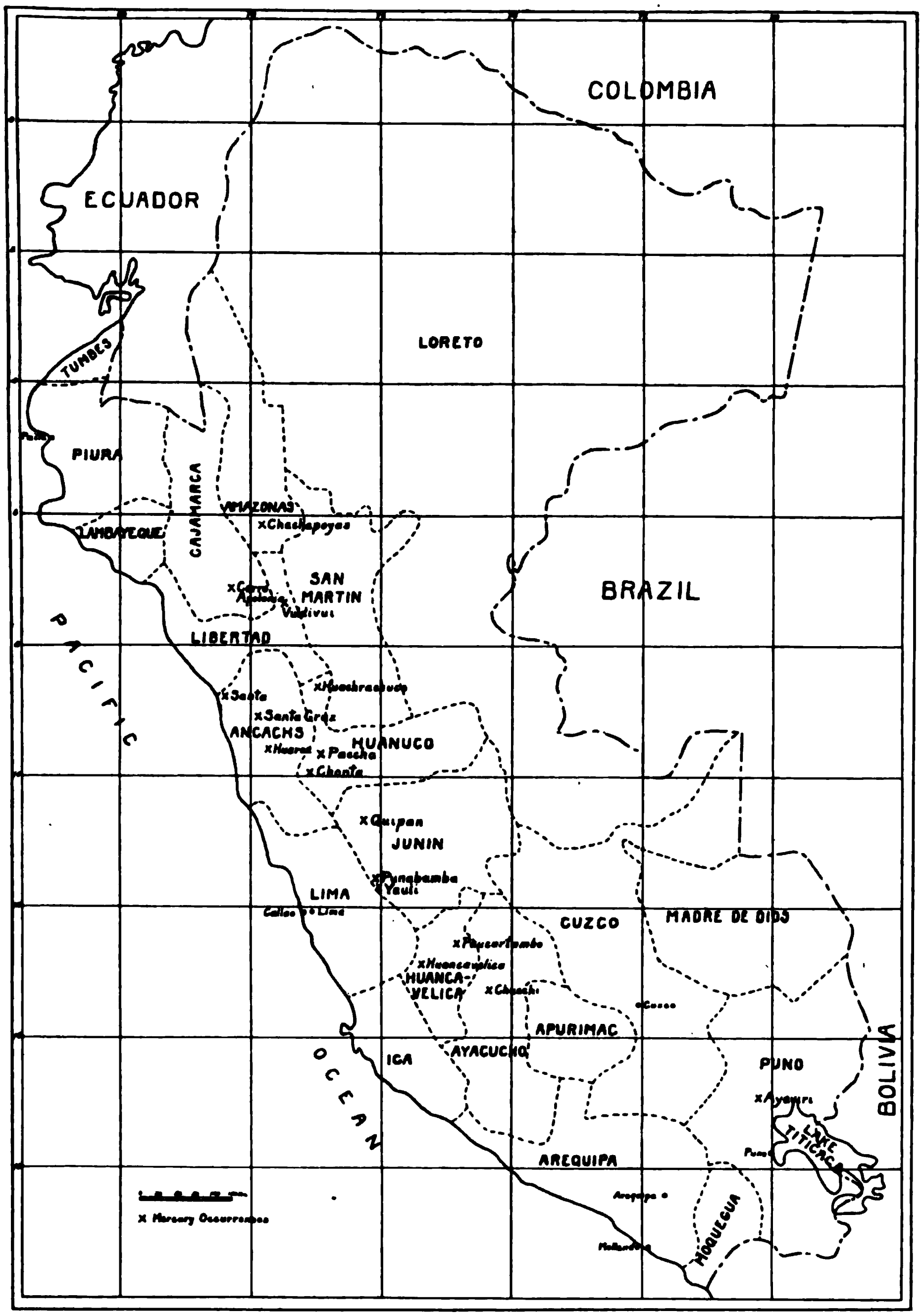
In the Cerro Apolonia near Cajamarca is a trachytic rock in which are inclined veins of a somewhat clayey nature full of small cavities containing globules of native mercury.

Humboldt notes the appearance of quicksilver at Vuldivui near Pataz.

Cinnabar is found at the Baths of Jesus southeast of Huachrachuco and at Paccha. The more important Chonta occurrence is also located in this department.

Humboldt mentions cinnabar at Huaraz and Santa in Ancachs. Of greater importance is the Santa Cruz occurrence near Caraz of which Raimondi gave the following description in 1873. Half a league above the hacienda Santa Cruz and 2-½ leagues from the town of Caraz is the Cerro Pampacocha, where there is a mercury mine. Three unsuccessful efforts were made to work the mine and it is now abandoned because of the low grade of the ore. In addition to cinnabar the rock contains small specks of argentiferous galena. Despite the scarcity of cinnabar, the Indians have produced more than 50 pounds of mercury by primitive methods. The mine is notable for violent explosions of carbonic acid gas which also hindered the efforts to exploit it.

du Chatenet says of Ancachs that mercury is found in only a small number of deposits which do not appear to be of much value. It always occurs as cinnabar mixed with other sulphides as galena, sphalerite, pyrite, and tetrahedrite. One of the principal mines is that of Santa Cruz near Caraz, where besides cinnabar there is also tetrahedrite and argentiferous galena. He also mentions the carbonic acid explosions which hinder mining operations. Although



Map of Peru showing occurrences of Mercury.

they do not impose an insuperable difficulty, the mine was abandoned at the time of his writing.

Becker states that the cinnabar in Ancachs is always found in veins mixed with such sulphides as galena, sphalerite, pyrite, and tetrahedrite.

At Quipan, near Cerro de Pasco, is a quicksilver mine. The rocks of the vicinity include granite and trachyte lavas and more or less metamorphosed sediments. Nöggerath says at the Hacienda Punabamba, 3 leagues from Morococha, in a side valley of the Andes on the bank of a mountain stream, are hot springs which deposit considerable sulphur. Above the springs are a number of quartz veins, which are cut by cinnabar stringers, that often unite to form small pockets of cinnabar. Locally the cinnabar content gives way to pyrite. Because of the small cinnabar content and the hardness of the veins, it has not been profitable to work them.

Pflücker y Rico gives a different description of what appears to be the same occurrence. He says the Pucayacu mine at the hacienda Punabamba does not seem to be of any importance as no formal operations have been attempted and it is idle. The cinnabar occurs in specks in a yellowish-white sandstone.

According to Crosnier, 1 league northwest of Pucará, in the Morococha region, are vertical beds of white sandstone, of which one with a thickness of 5 to 6 m. is impregnated with cinnabar. It is a fine-grained bleached sandstone that breaks into irregular fragments. The average mercury content is only .0025 to .003 per cent. The mode of occurrence is similar to that at Huancavelica. Becker mentions the occurrence of mercury ore in the Yauli district in schists and sandstones.

In the Department of Huancavelica is the noted Huancavelica district. In the District of Paucartambo, in the Province of Tayacaja of the same department, is also an occurrence of mercury ore.

Raimondi describes at Chuschi in the Province of Cangallo, Department of Ayacucho, the occurrence of mercury in a clayey earth of reddish color, formed from the decomposition and detrital material of volcanic rocks, which overlies a trachitic lava. It contains the mercury so finely divided that it can be extracted only by washing.

At Ayaviri in the Department of Puno native quicksilver is reported to occur in the pores of a trachyte. Becker suggests that the rock at this locality and in the Cerro Santa Apolonia is probably andesite rather than trachyte.

From the foregoing notes it is obvious that Crosnier's generalization that the Peruvian mercury occurrences are always in the same series of alternating shale, conglomerate, sandstone, and limestone with north-south strike and vertical or westerly dip, is not correct.

II. THE CHONTA MERCURY DEPOSIT IN HUANUCO.

Chonta is the only mercury occurrence outside of the Huancavelica district that has been developed to the point of yielding an appreciable output. The Chonta deposit was discovered by Manuel Perez Bustamente in 1756. Although regarded as an important discovery, regular mining operations were not undertaken until 1817. Rivero y Ustariz says that in 1828 only one mine was in operation producing less than 100 quintals (quintal=46 Kgs.) annually and in 1845 there were nine mines and eight furnaces producing at the rate of 60 quintals monthly. During the decade preceding 1850 there was an annual production of 200 to 450 quintals. A decline then set in and by 1862 production had ceased. In 1875 furnaces of the type used in California were installed for treating the ore and an unsuccessful effort made to resume mining operations. In 1908 the Empresa de Queropalca was working on a small scale ores containing 1 per cent silver and 10 per cent mercury from which the metals were extracted by lixiviation. The Peruvian Bureau of Mines credits Huánuco with a production of 1200 to 1500 kg. of mercury in the years 1906 to 1908, which doubtless came from the Chonta district. Since 1908 no mercury production has been reported from Huánuco.

According to Rivero y Ustariz, the cinnabar at Chonta is found in conglomerates, sandstone, clay, and limestone, associated with pyrite, argentiferous tetrahedrite, iron sulphate, and an elastic pitch which is highly fetid when burned. The ore occurs in threads and veinlets that unite to form rich pockets.

Nöggerath cites a description of the Chonta occurrence by Bugdoll. The deposit lies at an elevation of 12000 feet on a spur of the main Andes between Huallanca and Queropalca. Because of lack of capital and labor and lack of experience on the part of the owners, the property had been but little worked, although it had been productive over a period of some years and in 1862 was idle. The exposures were not adequate to reveal fully the nature ot the occurrence. At some points it consists of clay with included sand, pyrite, and cinnabar; at other points the cinnabar penetrates a footwall sandstone. Northwestward along the strike, the cinnabar disappears and the ore bed grades over into a pyrite bed which has not been prospected. A number of lead veins cut the cinnabar bed almost at right angles.

Raimondi describes three specimens from Chonta consisting respectively of cinnabar on sandstone, cinnabar on argentiferous tetrahedrite and pyrite, and crystalline cinnabar with calcium carbonate. He gives no description of the occurrence.

The last description of the district is given by Velarde, who says that the zone formerly exploited is more than 2 km. long. Veins with a north-south strike are interstratified with quartzite and sandstones. The metalliferous content occurs in pockets united by pyrite veinlets and consists of pyrite, sphalerite, galena, cinnabar, and tetrahedrite in a quartz gangue. The silver content of the ore ranges from 0.25 to 2.8 per cent and the mercury from 2 to 25 per cent.

III. THE HUANCAVELICA MERCURY DISTRICT.

LOCATION.

The city of Huancavelica lies in the province and department of the same name in the southwest-central part of Peru. It is situated in the valley of the Huancavelica River, a branch of the Mantaro River, on the eastern side of the western Cordillera, at an elevation of 3,972 m. The valley is deeply incised with steep mountain slopes on each side rising to heights of 700 to 1,000 m. At the townsite the valley floor widens a little, giving a relatively flat area on each side of the river. The main part of the town is on the south side of the river; that on the north side is known as the parish of San Cristóbal.

The city was founded in 1572 by Francisco de Angulo and given the name Villa Rica de Oro Pesa. In the Colonial period, when the Santa Barbara mine was producing considerable mercury, the city was flourishing and prosperous. It formerly supported nine churches a school in which physics, chemistry, and mineralogy were taught, and a hospital. Ruins of ancient buildings indicate a stage of culture and education much in advance of that found in the decadent and backward town of today. Eight churches, which still try to eke out an existence at the expense of the diminished and impoverished population, are monuments of the former splendor. Today the city is a backward town of several thousand inhabitants, consisting almost entirely of Indians.

Owing to the high elevation, the climate is quite cold. Rain with hail and snow is frequent from December to April. During the winter months, beginning in May, there are heavy freezes at night, but the days are clear and comfortable.

Huancavelica was formerly reached principally by way of the port of Pisco. This necessitated a five-day mule-back ride of 370 km; involving crossing the western Cordillera at an elevation of 4.900 meters. The completion of the railroad to Huancayo made the district more accessible by the trail from Huancayo through Izcuchaca to Huancavelica. But this route requires a journey of 120 km., or two days, on mule-back over a highly accidented trail. An extension of the railroad beyond Huancayo to Ayacucho is under construction and should soon be completed as far as Izcuchaca on the Mantaro River near the mouth of the Huancavelica River. If the developments now being carried on are rewarded with the hoped-for success, doubtless the construction of a spur to Huancavelica will be the next step.

PRODUCTION.

From the standpoint of production, the Huancavelica district ranks among the world's greatest mercury producers. For two centuries during the Colonial period the Huancavelica output equalled that of the famous Almadén mines in Spain. Due to the Crown tax on mercury much of the production during the Colonial period was smuggled out of the district and is not accounted for in the statistics of that period. The Spanish Crown books record an output of 104,046,931 pounds from 1571 to 1790. Subsequent to 1790 the production was small. Extant records show an output of 6,976,610 pounds from 1791 to 1813. From 1814 to 1835 there was no production. Rivero y Ustariz estimates the 1836 to 1839 production at 360,000 pounds. Strauss estimates the output from 1840 to 1909 to have been 1,000,000 pounds. From 1910 to the present about 20,600 pounds of mercury have been produced. The total production of the district has been, therefore, at least 56,202 tons of metallic mercury.

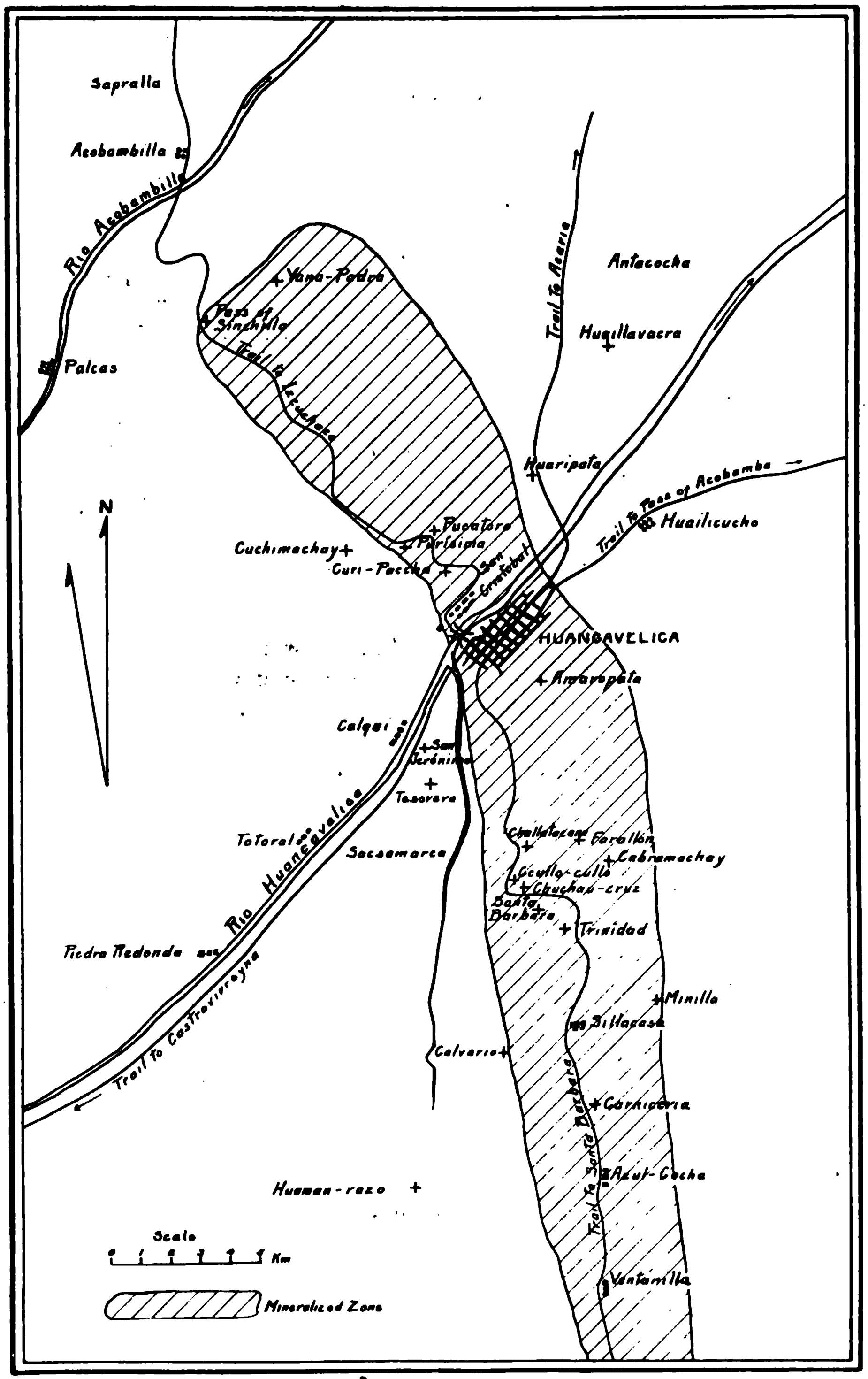
It is evident, therefore, that the great bulk of the Huancavelica mercury output was produced prior to 1790. Despite the great magnitude of the total production which has been spread out over a period of three and a half centuries, if Huancavelica had produced at the same rate as the California quicksilver mines in their early history, the 56,000 tons would have been produced in 40 years.

The usual annual production prior to 1790 was 4,000 to 6,000 quintals. During the period of maximum production in 1586 to 1589 an output of 10,500 quintals annually was achieved. For some years around 1680 an annual production of 7,500 flasks was maintained, but through the labor of over 4,000 Indians. Hawley says Almadén has produced nearly six and a half times as much with less than 1,000 men.

Until the collapse of the production toward the close of the eighteenth century, mercury mining was an exclusive prerogative of the Spanish Crown. In order to stimulate production then, the privilege was extended to individuals with the result that in 1794 the Government mines produced only 375 quintals whereas the privately-operated mines yielded 4,350 quintals. The district was practically abandoned during the years of the war for independence and has never since been an important producer. Crosnier says in 1852 the annual production was 2,000 quintals, half from the Santa Barbara and half from the other mines of the district. This must have been a temporary spurt, because the average annual output since 1840 has been only about 6 per cent of that figure.

EXTENT OF MINERALIZED AREA.

The center of mineralization in the Huancavelica region was the mountain immediately south of the town in which are the workings of the Santa Barbara mine. This mine and



Map showing the mineralized zone of the Province of Huancavelica.

the mines immediately adjoining it yielded almost all of the of the production of the district.

The belt in which cinnabar mineralization has occurred is far more extensive, however, and runs for miles both to the north and to the south, and attempts have been made to work the ore at many points. Ventanilla, 3 leagues south of Huancavelica, and Quiraquichiqui, 2 leagues to the north of the town, seem to be the only other mines that were at all productive. Innumerable other localities have been prospected, some of which yielded small productions over short periods of time.

Rivero y Ustariz lists 41 mines showing mercury ore which extend from 10 leagues south to 18 leagues north of Huancavelica. Crosnier's statement that cinnabar occurs in 41 mountains of which the farthest is 18 leagues from Santa Barbara is doubtless based on the list given by Rivero y Ustariz. The mineralization is not continuous throughout this mineralized belt. Thus the mercury-bearing sandstone of the Santa Barbara mine is barren on the north side of the Huancavelica River until the Quirarquichiqui mine is reached.

Crosnier's account contains brief descriptions of that mine and of the Ventanilla. At the time of his visit the Quirarquichiqui mine was almost full of water and was being exploited only by two or three Indians working on their own account. It is located in beds of calcareous sandstone and compact limestone. On the dumps are many fragments of sandstone traversed by veins of laminated calcium carbonate and some cobbles the size of a fist made up of radiating acicular crystals. The ore body at the Ventanilla mine is a series of irregular pockets and veinlets scattered through thick beds of compact, black and bituminous limestone in which are cavities filled with clear crystals of calcium carbonate. The cinnabar occurs in a yellow ferruginous clay which is sometimes impregnated with bitumen and is then nearly black. Some specimens very rich in cinnabar also contain small drops of native mercury. Crosnier mentions in addition an old abandoned mine almost full of water between the Ventanilla and the Santa Barbara where there is an outcrop of impure combustible material in argillaceous and calcareous beds. This association, together with the occurrence of the mercurial sandstone at Pucará in Junín in contact with the coal-bearing sandstone of that region he thinks is strong proof that the Peruvian mercury deposits belong to the carboniferous terranes of the Jurassic.

Hawley describes an occurrence at Azul-Cocha, 1-½ leagues from Huancavelica and a short distance north of the Ventanilla mine. An extremely hard vein of cinnabar in limestone was formerly mined here and the ruins of the old furnaces were still to be seen. The ore occurs in small branches or veinlets and as coatings on the rock and does not average over 1 per cent mercury. Nearby is another vein 5 feet wide which carries realgar and mercury. Adjoining it is an 11-foot vein of a black sooty material which appears to be a decomposed sulphuret. The vein is unusual in that it contains selenium which is associated with sulphur, mercury, arsenic, silver, and lead.

Arana says the mercury zone extends from Palcas, 4 leagues north of Huancavelica, to Huachocolpa, 9 leagues south and has a width of 3 leagues from east to west. The area of greatest mineralization lies between Huancavelica and Ventanilla on the south side of the Huancavelica River and between Huancavelica and Yana-Padre on the north side of the river.

HISTORY OF HUANCAVELICA DISTRICT.

The history of the Huanavelica district is largely a history of the Santa Barbara mine, the rest of the mineralized belt having played a very minor rôle in the mercury production. The earliest history is somewhat legendary. The ores were known to the Indians prior to the arrival of the Spaniards and utilized by them as a pigment under the name "limpi."

It is not certain whether they knew how to extract the metallic mercury or not, though Rivero y Ustariz says in the vicinity are remains of ancient, very small, retort-shaped furnaces in which the Incas reduced cinnabar.

Strauss relates the Huancavelica legend that an archbishop who was traveling eastward to Ayacucho in 1532 was offered silver water to wash with at an Indian hut where he had put up for the night. He sent specimens of mercury and cinnabar to Spain, which resulted in the development of the deposits by the Spanish Crown and the beginning of production on January 1, 1571.

According to other accounts the occurrence was first called to the attention of the Spaniards in 1566. Becker and Velarde credit Enrique Garcés with the discovery of the Santa Barbara locality in that year. Rivero y Ustariz and Arana say that an Indian belonging to Amador Cabrera called his attention to the mercury ore, the former giving 1564 as the date. At all events during the first few years after the discovery the deposit was in possession of and worked by Cabrera.

In 1569 the Viceroy Francisco de Toledo reached Lima and claimed the mines for the Spanish Crown and reserved for the Crown all deposits lying within a radius of 10 leagues around Huancavelica. In 1570 Cabrera was paid 250,000 duckets by the Crown for his mines. Operations were rapidly expanded and Huancavelica speedily became an important producer of mercury. It was a most opportune and fortunate discovery as Huancavelica supplied the mercury required for the treatment of the silver ores that began to be mined at many localities in Spain's American possessions. In the Colonial period Huancavelica mercury was used in Peru, Bolivia, Chile, and as far north as Mexico. The Santa Barbara mine was heralded at that time as "the greatest wonder of the world" and "the most precious jewel of the crown."

A considerable output of mercury was maintained for over two centuries. But incompetency and prodigality in the direction of the exploitations over and over again placed the property in a precarious state and caused it to pass through many vicissitudes, until finally its complete collapse and virtual abandonment resulted near the close of the eighteenth century. At first the mine was administered by officials sent out directly from Spain by the King. Many of them had no knowledge of mining whatever, and the condition of the mine became so critical that it was finally handed over to the "Gremio de Mineros," a sort of miners' union. This organization was obliged to deliver the entire output to the Crown at a fixed price. The arrangement proved unsatisfactory also and was terminated in 1785.

The root of the difficulties in working the Huancavelica mine was the lack of a systematic and far-sighted policy in conducting the operations. The administrators sent out by the Crown were interested in making a good showing with the largest possible production of mercury with little regard of the effect the extraction of the mercury ore might have on the safety and future of the mine. The temptation was to rob the mine of the richest ore in sight; and often, when production began to fail, pillars left by more prudent administrators were removed to help in maintaining output. This procedure rendered more difficult subsequent operations and was the cause of a number of serious collapses of the mine workings. The Gremio de Mineros was forced to similar practices. As they received an arbitrarily fixed price for their output, the temptation was to take out the richest and most easily removed ore in order to keep the immediate cost of production at a minimum with little regard of the consequences. These methods of operation resulted in a series of cavings of the mine, several of which were highly disastrous in loss of life and in material damage to the mines.

A big collapse in 1681 paralyzed work and made large expenditures necessary to reopen the mine. The ore that fell into the San Jacinto workings was extracted and yielded 4,000 flasks of mercury. Hawley cites a collapse in St. Domingo de Cochapata, in the bottom of the mine, as a result of which over 100 Indians were buried. The most terrible collapse of the mine occurred in 1786 under the administration of Marroquin, whose name the ruins bear. Crosnier says two hundred workmen were buried and a funnel-like hole 8 to 10 m. deep and 60 to 70 m. in circumference was formed. Umlauff gives the depth of the hole at 60 m. The enormous mass of caved rock affected the workings to the bottom of the mine. The collapse resulted from the removal of rich pillars and supports by Marroquin who had been sent from Spain in order to increase the greatly diminished output of the mine. The mine has never recovered from this catastrophe and production since that date has been small.

The Spaniards spent much money, often in a very extravagant way, in the construction of tunnels to get at the ore body at lower levels. The principal tunnels built by them were the San Nicolás and San Javier, cutting the ore-bearing zone from the east, the Belén and Chaclatacana, cutting it from the west; and the Pochcocc or Ulloa at the north end close to the town. The level of the San Javier tunnel was 56 m. below the summit of the deposit, the Belén tunnel was located 160 m. below the top of the ore body, and the Pochcocc tunnel only 32 m. above the level of the plaza in Huancavelica and 520 m. below the Belén tunnel. The Pochcocc tunnel was started in 1763 by Antonio de Ulloa. The portal is located at the north end of the Grand Farallón on the edge of the town of Huancavelica and it was intended to drive along the west contact of the sandstone horizon until the mineralized rock was reached. The tunnel was not driven more than 60 meters and was abandoned before cinnabar was encountered. The most extensive piece of work carried out by the Spaniards was the

Belén tunnel which Hawley says cost the Spanish government 1-¼ million dollars. It was begun between 1601 and 1617 and completed in 1642. It is the lowest of the tunnels that reached the Santa Barbara ore body. Its length is variously given as 560 to 600 meters, and it was 3 to 4 meters wide and high. The mine workings extended to an unknown depth below this tunnel. Their total depth below the outcrop has been estimated at 350 meters. Crosnier gives as the horizontal extent of the mine workings 500 meters along the beds, and 104 meters as their width at the surface and an average of 60 meters in the lower workings. In so far as they are not caved, the mine workings consist of large irregular excavations supported by solid masonry pillars.

After the collapse of 1786 various measures were resorted to with the hope of being able to bring the mercury production up to its former figures. The King of Spain consulted German metallurgists and engineers and in 1790 Baron Nordenflicht was sent to Huancavelica to report on the situation. His recommendations were approved by the King but were not carried out by the intendente, Count Ruiz de Castilla. In order to stimulate new discoveries, in 1792, discoverers were granted the privilege of working new deposits. In 1793 individuals were permitted to rework the old dumps. This free exploitation had the desired effect for a few years; and in 1794 the independent mines were about supplying the deficiency in the Santa Barbara output. Efforts to recussitate the Santa Barbara mine were abandoned about 1795. Among the important independent mines at this time were the Trinidad and the Sillacasa.

Upon the recognition of Peruvian independence in 1821, the new government claimed title to the Crown properties. No serious attempts to resume operations appear to have been made, however, until 1836. In that year a strong company was formed under the auspices of the Protectorate government and the miner D. Demetrio Olabegoya was placed in charge. It was planned to put the mine in shape to supply sufficient mercury for Peruvian needs. This company was dissolved in 1839 by the Liberator government and a new company formed which, according to Rivero y Ustariz, was composed of generals, colonels, and others who had no mining knowledge and were also without the necessary resources to develop the property. At any rate after ruthlessly gutting the workings for two years, the company failed and was dissolved in 1841 by the Prefect Montoya who replaced it by the Compañia Huancavelicana. Political disturbances interfered also with this quasi-official company, so that the government finally leased the property in 1846 to D. Luis Flores for ten years at 1,000 pesos annually.

During the last half of the nineteenth century many attempts were made to interest private companies in the exploitation of the Santa Barbara mine and numerous proposals were received. Arana says these negotiations always failed because of political difficulties, because the government holdings did not include the territory from which the small current production was being derived, and because the government did not have the requisite data to enable it to delimit the property it claimed. Consequently during most of that period the mine was abandoned to a few Indians who collected and reduced small quantities of ore from the surface workings.

In 1901 the property was opened to denouncement under the Peruvian mining laws, but it was in such bad shape that the large sums of money that would be necessary to rehabilitate it continued to deter any one from reopening the property. Pedro P. Arana tried without success to raise capital for that purpose in 1901; and subsequent efforts proved equally unsuccessful until the well-known Peruvian mine operator, E. E. Fernandini, became interested in 1915.

NEW DEVELOPMENTS BY FERNANDINI.

The magnitude of the task of rehabilitating the Santa Barbara mine is attested by the fact that although the work was started in 1915 the property has not yet reached the productive stage. Fernandini is the largest and most energetic Peruvian mine operator and has at his command ample resources to carry on the work. It has been prosecuted with reasonable diligence and adequate financial support, and the lack of results thus far is indicative of the enormousness of the job.

The larger part of the mercury-bearing ground of the Santa Barbara mine and vicinity had gradually been acquired by Augusto Benavides and was purchased from him by Eulogio E. Fernandini in 1915. In 1916 Fernandini initiated a program under the direction of the Peruvian mining engineer, A. Gastelumendi for the development and resumption of operations on the old Santa Barbara ore body. The Belén tunnel was traversable for a distance of 280 m. Over a year was spent in cleaning it out beyond that point. It was found to continue to 508 m. in a straight line with a 1 per cent slope and then give way to an inclined sinuous gallery 126 m. long, the end of which was 33 m. lower than the entrance to the tunnel.

A new tunnel was started 213 m. below the Belén tunnel which will have to be driven 1,250 m. to reach a point beneath the center of the Brocal. Gastelumendi considers it very doubtful that the old Santa Barbara workings extended much below the level of the Belén tunnel. Hence it is planned to extend a raise from the Neuvo tunnel to the Belén tunnel level on reaching the ore-bearing zone, and to exploit the territory between the two tunnel levels, and subsequently to work the ground below the level of the Neuvo tunnel by means of inclines. Before the work on this tunnel could proceed it was necessary to install a power plant.

The stream and the steep gradient of the Quebrada de Sacsamarca are utilized for the hydroelectric plant. A ditch 1,106 m. long gives a head of 140 m. which is transmitted from the storage tanks to a Pelton wheel by a pipe line 339.45 m. long and .305 m. in diameter. The Pelton wheel is connected with a three-phase generator of 80 kw. and 400 volts. For transmission to the compressor this potential is raised to 4,800 volts by means of six 15-kw. monophase transformers. The compressors are situated 1,300 m. from the power plant near the mouth of the Nuevo tunnel. There are six compressors driven by six three-phase 15 H.P. motors. The shops are also located here and utilize the electrical force. These installations were not completed until 1918.

In 1919 the Nuevo tunnel was being driven by two 11-hour shifts at the rate of 40 to 45 m. monthly. The work was being done by contract with a sliding scale of payment as an incentive to rapid progress. A 50-cm. guage track is being laid in the tunnel.

At the same time that the mining developments are being carried out experiments are being made in the treatment of the ore for the recovery of the mercury. Two small furnaces, 9 m. high, holding a total charge of 7 tons, have been erected at the mouth of the Belén tunnel. They are after the pattern of those in use at New Almadén, California, and at some of the European localities. The ore passes through the furnaces at the rate of 200 to 500 kg. every three hours. Taquia (llama dung) is used for fuel and it requires 10 per cent more fuel than ore. The taquia costs 6 to 8 soles per ton (about $3 to $4 per ton). The furnaces are run at a temperature of 800 degrees C. and the losses of mercury are 17 to 20 per cent. The sublimed gases are passed through a series of 9 chambers to condense and collect the metallic mercury.

The ore used in these experiments is obtained chiefly from the accessible old workings of the Brocal and averages .2

per cent mercury. It is estimated that it will require .5 per cent ore to pay all costs. Flotation concentration will be employed for low-grade ores and slightly impregnated rocks. Experiments made at Fernandini's Huancavelica plant gave excellent results.

GEOLOGY OF THE DISTRICT.

Resumé of earlier descriptions.—Despite the considerable literature on the Huancavelica district, prior to the visit of the Williams Expedition, there was not much information available about its geology. The literature of the seventeenth and eighteenth centuries, as one might expect, has little to say about that subject. During the last century the district was of far less importance and the underground workings for the most part inaccessible, so that little in the way of specific information was contributed. In 1904 the report of A. F. Umlauff was issued by the Peruvian Bureau of Mines, which constitutes the first real attempt to describe the geology of the district.

Crosnier says that both sides of the Huancavelica Valley are bordered by upturned sediments forming escarpments as high as 300 m. Wide places in the valley are filled with modern alluvium. The nearly vertical strata are composed of alternating beds of blackish-gray compact limestone with innumerable white veinlets of calcite, coarse quartz sandstone, yellowish or white in color, gray or nearly black shale, and limestone conglomerates. He describes the following section in the Belén tunnel from the portal to the mine workings:

Breccias and conglomerates with pebbles and cement of limestone and traversed by calcite veinlets. More than 100 m. thick.
Alternating beds of compact limestone and shale with calcareous cement and cut by calcite veinlets.
Compact blackish limestone with veinlets of crystallized calcite.
Hard brown shale.
Siliceous sandstone.
Thick beds of hard shale.

Hawley contributes less to the geology of the district. He merely mentions that the strata containing cinnabar are light-colored sandstones with occasional layers of bluish-gray limestone, that rise almost vertically from the valley with a north-south strike and steep westerly dip.

Torrico y Mesa cites the following section across the Grand Farallón from west to east: limestones, limestone conglomerates, white sandstone, greenish shales, shales, coal beds, red sandstone, clay, and limestones. The limestones are of various colors, as white, blue, and yellow, are of compact texture, and are cut by a multitude of calcite, calcium sulphate, and quartz veins. The white sandstone is more or less coarse-grained and alternates with thin beds of greenish shale. The coal is very thin and much mixed with pyrite and with a conglomerate formed by thick nodules of quartz. Pyrite is also abundant in the sandstone. The strata strike N. 20 degrees W. and dip steeply to the west.

Arana's account of the geology of the district is based on data taken from C. Marques who says the mountains are formed of limestone, schists, sandstones, conglomerates, and porphyries, alternating in beds of considerable thickness, with a northerly strike and westerly dip. The limestone is usually compact, whitish or bluish in color, and cut by many veinlets of quartz, gypsum, and calcite, and contains pelagic shells. The sandstones are of various colors—dirty-white, yellowish, reddish, light and dark lead—and contain fossils.

Much more detailed is the account of the geology given by Umlauff, which is also accompanied by a geologic map of the mineralized belt. He describes both sedimentary rocks and igneous rocks.

Limestones are the most abundant. They are concretionary, crystallized, crystalline, and compact, and of various colors from white to black. Fractures traverse them in various directions which owe their origin to contractions subsequent to igneous intrusion. Fossils of Cretaceous age, for the most part molluscs, are described as very numerous. There are also abundant siliceous nodules.

Conglomerates form superficial deposits of considerable extent. They are post-Cretaceous age, and the Cretaceous fossils which they contain came from the strata from which the conglomerates are derived.

The cinnabar occurs chiefly in a fine-grained, coherent sandstone. The latter has sometimes a blackish and greasy appearance due to the presence of bituminous substances, and also contains pyrite, arsenopyrite, and stibnite. Its cement is usually siliceous, but is sometimes argillaceous and calcareous, the latter in the vicinity of the limestone.

Intercalations of shale, 2 to 5 m. thick, with foliation parallel to the stratification of the enclosing rocks, occur in the limestone and sandstone. Occasionally they alternate with very fine clay.

Umlauff also describes the calcareous tuffa in the vicinity of the San Cristóbal thermal springs on the north side of the city. The deposit he says covers more than a square kilometer and has a thickness up to 15 m. He believes that the excess carbonic acid of rain water dissolved limestone forming calcium bicarbonate, and that on the loss of the excess carbonic acid, the calcium carbonate of the tuffa was deposited.

Umlauff's geologic map shows basalt, porphyrite, and andesite, but the report describes only basalt and andesite. The basalt is encountered west of Huancavelica. Fractures in it contain veins of silver, lead, copper, and mercury. The map shows large areas of porphyrite to the east and south of Huancavelica. The andesite is described as cutting the sandstones and limestones in irregular pockets with dimensions of a few millimeters to 25 to 30 meters and having small branches extending out from the main mass. Sometimes the andesite is accompanied by quartz and other vein

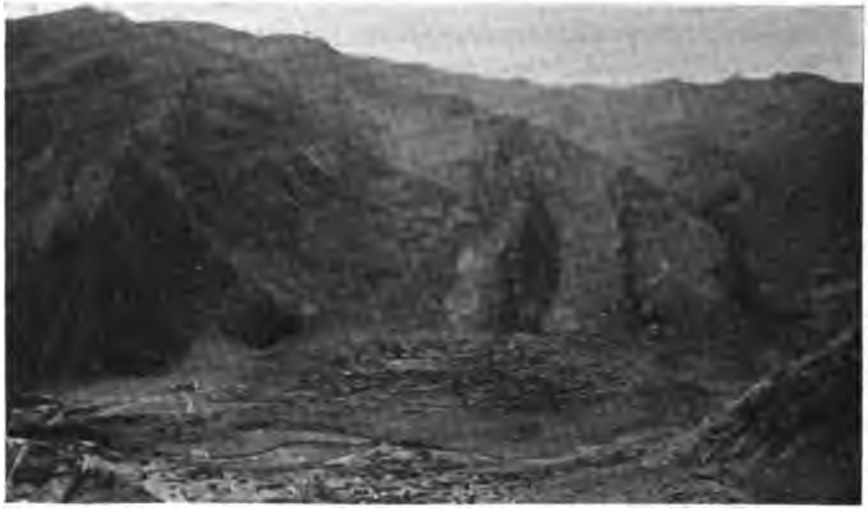


Fig. 1.—View looking north across Valley showing the vertical Grand Farallón limestones.

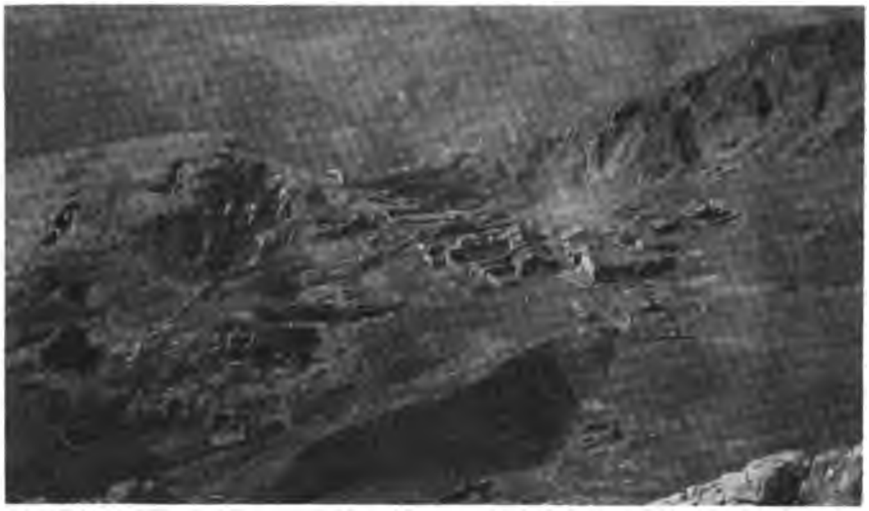


Fig. 2.—View looking north showing Botija Puncu mine.

materials and almost always by an abundance of iron pyrite.

Dueñas says the mercurial outcrop is a subordinate member of a series of sediments comprising siliceous sandstones, limestones, and limestone conglomerates, all of which have been dislocated and folded. The andesites and basalts which surround the mercurial mass throughout almost its entire extent represent intrusions into the fissures and flows out of them.

Velarde states that the ore deposits occur in a sedimentary series of siliceous sandstone, limestones, and conglomerates, which are dislocated and folded. They are cut by andesite and basalt dikes.

Strauss describes the mineralization as intimately associated with sandstone, limestone, and calcareous conglomerate which have suffered folding, probably due to the later eruptives—the basalt, porphyry, and andesite. The basalt lies immediately west of the Santa Barbara mine.

Gerth says the mercury occurs in a light quartz sandstone which outcrops with a steep dip on both sides of the Huancavelica Valley at the town. At the Santa Barbara mine it is overlain on the west side by marly beds which contain Aptian fossils, and on them follow thick limestones. Farther west appear representatives of the porphyrite formation that makes up the mountains above Huancavelica.

The preceding accounts of the geology of the region are very generalized and for the most part so vague that they do not give much information about the stratigraphy, petrography, and areal distribution of the rocks. Although far from complete and detailed, the authors' observations permit them to describe with much greater specificness the lithology of the rock units exposed in the central part of the district in the vicinity of the Santa Barbara mine and the city of Huancavelica.

The Grand Farallón limestones.—Rising precipitously above the city on both sides of the Huancavelica valley is a series of steep westerly-dipping beds, which are being called the Grand Farallón limestones. They are characterized by wide and frequent variations in chemical composition. There are transitions from pure limestones, through increasing argillaceous content into shales, and through increasing silica content into sandstones and quartzites. Most abundant in the series are beds of argillaceous and siliceous limestone. About 250 meters stratigraphically above the Grand Farallón sandstone is a well-marked horizon of cherty limestone characterized by bands and nodules of chert.

A prominent feature of the Grand Farallón series is a great ledge of massive, and in many places remarkably porous, sandstone. It extends across the river in a direction a little west of north at the town of Huancavelica. The outcrop on the south side is so prominent, forming a ridge that projects above the limestones on each side of it, that it is called the Grand Farallón. The thickness of this sandstone is between 50 m. and 100 m. On acount of the mass of debris which covers the ground on each side of its outcrop, the contact of the Grand Farallón sandstone with the beds on each side of it is generally obscured. On top of it, that is, on its west side, is a horizon of shale nearly 100 m. thick in which are gray, red, and green zones.

In the mass of debris and old dumps about the cave-in of the Hundimiento Marroquin, the prominent outcrop of the Grand Farallón sandstone suddenly terminates. With like abruptness, a similar sandstone with equally prominent outcrop appears 600 m. to the southeast and with a southeasterly dip swings around to the northeast toward the Huancavelica River some distance below the city. A series of shales similar to those above the Grand Farallón sandstone overlies this sandstone. The thickness of both the sandstone and the shale is much greater here, however.

The Grand Farallón sandstone is made up of small, well-rounded quartz grains, ranging for the most part from ¼ mm. to ¾ mm. in diameter. When unmineralized, the

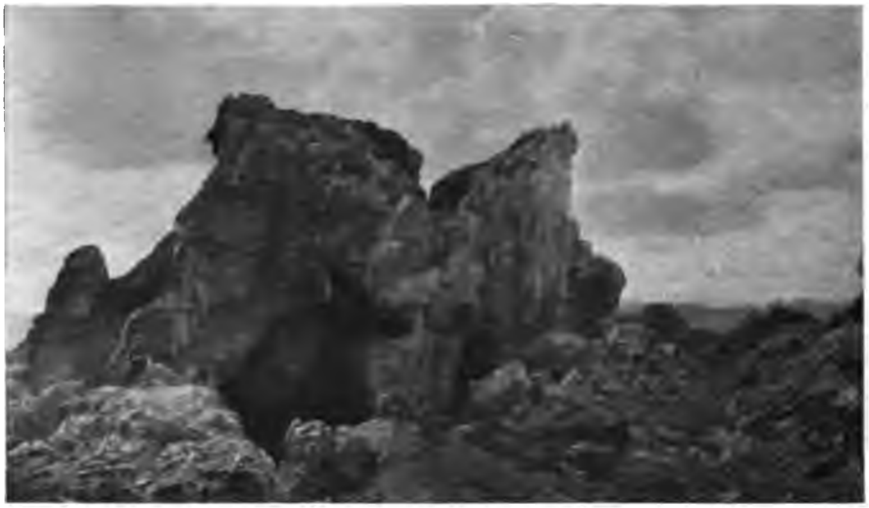


Fig. 1—View showing caved Brocal at south end of outcrop of the Grand Farallón.

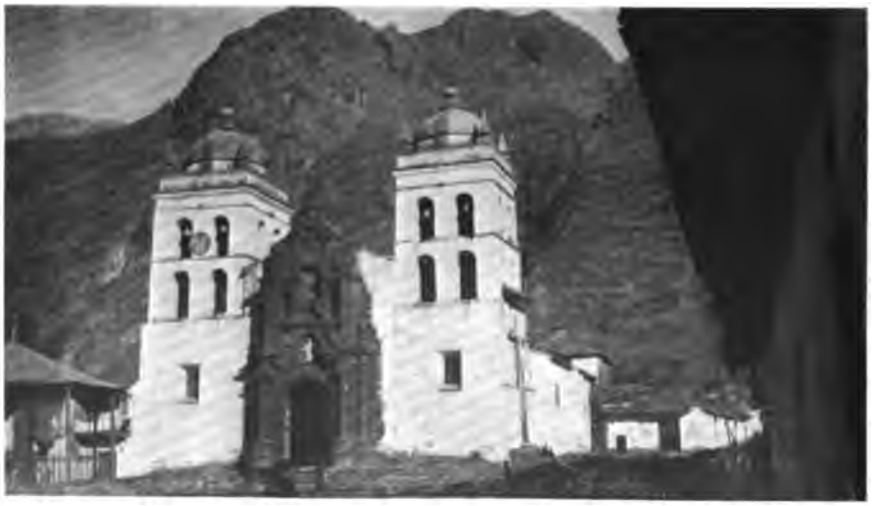


Fig. 2.—Plaza Independencia showing Grand Farallón in the back ground.

matrix of the sand grains is siliceous, consisting of very fine-grained quartz.

A part of the Grand Farallón limestone series is exposed in the Nuevo tunnel. The rock traversed by the tunnel is for the most part limestone. Intercalated in the limestones are numerous bands of dull reddish shale varying in width from a fraction of a meter to 4 to 5 meters. Planes of slipping and faulting are numerous, most of them parallel to the stratifiation but some cut across the bedding planes. At the entrance to the tunnel the strata have the direction N. 10-15 degrees W. 73 degrees W. About 225 meters from the portal of the tunnel is a fault plane with the direction N. 65 degrees W. 65 degrees W. with black gouge ½ m. wide. Just before reaching the fault plane, the tunnel passes through 50 feet of decomposed fine-grained igneous rock. Beyond the fault plane the bedding of the limestone is well-defined and has a strike a little east of north and a westerly dip of 60 to 80 degrees.

The Conglomerate limestones.—Southwest of the Grand Farallón limestone, a second series of limestones outcrops in a belt with a southeasterly trend. The upper part and greater thickness of this series consists of conglomerates made up of pebbles, boulders, and cobbles of limestone. The fragments range in size from small pebbles to boulders more than 20 cm. in diameter, and in general are but little water-worn and rounded. The matrix of the conglomerate varies from fairly pure calcium carbonate to a reddish sandy material. The lowest beds of the series are not conglomeratic.

Umlauff regards the conglomerates as late surficial deposits but their geologic relations are against such an interpretation. Their strike and dip bears no relation to the present topography. They are covered by an igneous flow below the junction of the Quebrada Santa Barbara with the Quebrada Sacsamarca. They are mineralized at a number of places, as at the Trinidad and Florida mines, and are hence older than the period of mineralization.

Quaternary deposits.—The Huancavelica Valley is covered with alluvium and with extensive deposits of calcareous tufa. The latter deposits are still being formed about the orifices of warm springs that emerge at a number of points in the valley floor. The San Cristóbal springs are utilized at the public baths on the north side of the city. Their waters range from 30 to 35 degrees C. These tufas contain much fragmentary plant material, the only determinable form being a large reed which still grows in wet places in the valley.

The igneous rocks.—Igneous rocks are abundant in proximity to the mineralized zone. A large area to the southwest of the Santa Barbara mine is underlain by them. Another large intrusion separates the two series of limestones over most of their outcrop. In addition to these, many smaller areas of volcanic rocks occur. The outcrops of the rocks are so highly decomposed that it is difficult to determine definitely their original character. They appear to have been chiefly of andesitic character with gradations to trachyte. At the Nueva claim, a short distance south of the area shown on the geologic map and along the line of the mineralized zone, occurs a quartz porphyrite.

The rock along the northeast edge of the large igneous area southwest of the trail to the Belén tunnel in the Quebrada Santa Barbara is a light-gray to white scoriaceous rock. Some of it has a hard porcelaneous appearance, some a soft kaolinic appearance. The texture ranges from felsitic to porphyritic with sanidine phenocrysts averaging about 1 mm. in size. The rock appears to be an altered trachyte. Below the Belén tunnel, the Conglomerate limestones are overlain by light-colored stratified tuffs, including fragments of limestone, and these in turn by the trachyte. At the junction of the Quebrada Santa Barbara and the Quebrada Sacsamarca the rock overlies the Conglomerate limestones and has a columnar structure. At least this margin of the igneous mass is, therefore, a lava flow.

The narrow igneous intrusion in the Conglomerate limestones that cuts across the Quebrada Sacsamarca north of the igneous mass described in the preceding paragraph is a sill in those limestones. It consists of a dark purplish-gray rock which is highly altered and has numerous patches of calcite running through it. It appears to have been an andesite.

The large outcrop of igneous rock with irregular boundaries that lies between the outcrop areas of the two series of limestones represents an intrusion. It is a dark-gray to purplish andesitic rock ranging in texture from felsitic to porphyritic. It is also considerably altered and permeated with calcite.

The long narrow outcrop west of the Grand Farallón is an intrusion that lies more or less parallel to the bedding of the enclosing limestones. The rock is even more highly altered than those already described. Some of it is traversed by veinlets and elongated patches of coarsely crystallized calcite more than 5 cm. long and as much as 1 cm. wide. Another facies has blotches of greenish talc, averaging about 5 mm. in diameter, that seem to represent altered phenocrysts of a porphyritic rock. From the porphyritic facies all gradations are represented to a non-porphyritic aphanitic rock. The prevailing color is purplish. Some of the highly weathered rock has a limonitic color. The fresh rock of this intrusion was doubtless an andesite.

GEOLOGIC STRUCTURE.

In none of the literature on the Huancavelica district is there an attempt made to discuss the structural geology. The sum total of references to structural features in the literature is included in the section giving a resumé of earlier descriptions of the geology of the district. The outcropping edges of the highly-inclined, westerly-dipping beds on the steep mountain slopes on both sides of the Huancavelica Valley at the city are so striking a feature that most authors have referred to it. Beyond that little structural information is given.

A number of the later writers mention the igneous rocks but as a rule say nothing about their mode of occurrence. Dueñas says they include both intrusives and flows. Umlauff mentions the occurrence of irregular pockets of andesite that cut the sandstone and the limestones, and gives a geologic cross-section in which his porphyrite is shown intrusive into the limestones and in which the basalt at the west edge of the section is shown in a structural relation to the limestone conglomerates that is not altogether clear.

Dueñas describes the sedimentary rocks as dislocated and faulted, and Velarde makes the same reference to them. Strauss says they are folded as a result of the igneous intrusions. No more specific references are made to the structure of the sedimentary strata.

The uniform steep westerly dip of the Grand Farallón sandstone and the beds adjoining it gives way to more complicated structure at greater distance from the sandstone. The areal geology and the observations in the tunnels show clearly that the district is one of tight folding with much slipping along bedding planes and the development of jointing. The frequent discordant strikes and dips and the separation of the two big sandstone outcrops indicate considerable faulting also. The two great sandstone masses appear to belong to opposite limbs of an anticline whose axis pitches toward the southwest and the nose of which has been faulted out.

The structural relations of the two limestone series are not clear. Over the greater part of the area mapped, they are separated by the large andesite intrusion. Where it pinches out and the two series come in contact at the Hundimiento and to the south, the beds are so much disturbed and the outcrops are so meager that their relations could be determined only by much more detailed work.

It is clear, therefore, that the principal mineralized area of the Huancavelica district is coincident with an area of great disturbance.

GEOLOGIC HISTORY AND CORRELATION.

The geologic history of the Huancavelica district as unfolded by the rocks involved in the areal geology begins with the deposition of the Grand Farallón limestones. The literature gives little trustworthy information concerning the age of these strata or of the rocks that are younger than they.

Crosnier says all of the Peruvian mercury occurrences are located in beds of Upper Jurassic or Middle Jurassic age. Nöggerath credits von Leonhard with referring them to the Kohlengebirge.

Umlauff distinguishes stratigraphically between the limestones with intercalated sandstone and shale on the one hand, and the limestone conglomerates on the other hand. The Grand Farallón sandstone is described as containing a few Cretaceous molluscs and other forms and the limestones of the district as containing an abundance of Cretaceous molluscs and other forms. What these Cretaceous forms are he does not state. It is also misleading to describe the Huancavelica limestone as abundantly fossiliferous for our observations indicate that fossiliferous strata are not numerous and fossils in them are scarce. Unlauff considers the limestone conglomerates as superficial deposits of post-Cretaceous age.

Strauss limits himself to the statement that the limestone contains Cretaceous fossils. Gerth says the Huancavelica region consists of Cretaceous beds, and that the Grand Farallón sandstone is overlain by marly beds that contain Aptian fossils which are succeeded by thick limestones.

The later writers agree, therefore, on the Cretaceous age of the Huancavelica limestones, but do not present the evidence on which they base the conclusion.

A few fragments of fossils were noted at a number of places in the limestones, but the rocks are so dense and massive that, as a rule, even the fragments could not be extracted in a way that would permit of their identification. In the strata that lie immediately beneath the Botija Puncu mine is a ledge of limestone which is more highly fossiliferous and which contains complete forms that weather out in such a way as to yield fair material for determination. A collection from this locality is described in a subsequent section. The age of the fauna is Upper Cretaceous. It occurs in the thick limestones above the marly beds that Gerth says contain Aptian or Lower Cretaceous forms. Since Gerth does not name or describe the forms upon which he bases his correlation, Upper Cretaceous age will be assumed for the entire series of beds.

The Botija Puncu fauna fixes the Upper Cretaceous age of the Grand Farrallón limestones. A more difficult problem is to determine the stratigraphic relations of the Conglomerate limestones. As noted in the description of the series, the lower beds consist of ordinary limestones; the upper beds are coarse, not very water-worn conglomerates. The two series of limestones are separated through most of their extent by an irregular intrusion; and in the vicinity of the Santa Barbara mine and to the south, where the igneous rock has pinched out, their contact is obscured by lack of outcrops. No fossils were secured from these strata upon which an age determination might be based. The lower beds carry a few fossils, but they are so fragmentary and so difficult to extract that to secure determinable material would require more time than was available. They suggest, however, comparisons with certain almost equally obscure occurrences of Upper Cretaceous brackish fossils found in the eastern Andes of Bolivia.

The correlation of the Conglomerate limestones must be arrived at indirectly and largely by inference. The limestones at the base of the series are in all probability a part of, or a continuation of the limestones of the Grand Farallón series, and hence are of Upper Cretaceous age. Subsequent to their deposition, these limestones were consolidated and uplifted above sea level and subjected to erosion. The heavy limestone conglomerates that are in the nature of a basal conglomerate were then formed. This took place, therefore, at the close of the Cretaceous or in early Tertiary time.

The whole series of strata were folded and faulted. While these orogenic movements were going on, or at their close, a period of volcanic activity set in, marked by intrusions of irregular masses and sills and by surface flows. These processes were accompanied by or terminated with an uplift. A cycle of erosion followed which developed the relatively mature topography that is preserved today in the upper slopes of the mountains. Further uplift caused the incision of the youthful topography that is still being developed and which determines the configuration of the lower slopes of the mountains and the deep cañon-like valleys of the major streams.

The part of the geologic history of the Huancavelica district described in the preceding paragraph extended from the early Tertiary to the present. The district affords no criteria by means of which the time and duration of the volcanic activity can be fixed closely. It came to a close before the beginning of the older of the two cycles of erosion represented in the present topography, and consequently certainly terminated before the end of the Tertiary. If Bowman's dates * of origin of the principal topographic forms of the Andes be accepted as applicable to this region the period of igneous activity was Miocene or older. His evidence indicates that the final development of the more mature upper slopes of the mountains took place in Miocene or early Pliocene time. On this basis, the volcanic activity of the Huancavelica district was Miocene or older Tertiary in age. If the thermal springs have any genetic relation to

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* Bowman, Isaiah: The Andes of Southern Peru, 1916, pp. 185-186.

the igneous activity, if they represent the final phase of it, one would tend to push the period of igneous action as far forward as the facts warrant, that is, into the Miocene.

THE MERCURY DEPOSITS.

Previous descriptions.—De Rivero gives no description of the Huancavelica deposits. He states that the tenor of the Santa Barbara ores was low, averaging not more than ½ per cent, although pockets of richer ore were encountered from time to time.

Crosnier describes only the ore in the Grand Farallón sandstone. The ore-bearing sandstone varies in hardness, color, and grain. Sometimes it effervesces slightly with acids and sometimes it has a little argillaceous cement but more commonly it is solely siliceous. It is almost everywhere impregnated with cinnabar, but with extreme irregularity. Some pillars in the upper workings contain 2 and 3 per cent and more of metallic mercury whereas in depth the mercury content is only .001 or .002 per cent and only rarely as high as .008 to .010 per cent. The ore body was richest and widest at the summit of the mountain; and, during the first two centuries of exploitation, it was not rare to encounter in sandstone highly impregnated with cinnabar, irregular veinlets and masses of pure laminated cinnabar. The sandstone is also frequently impregnated with arsenopyrite. It is then heavier and harder, speckled with realgar, and richer in mercury. Realgar is more abundant in the lower levels in numerous irregular veinlets of massive realgar with small druses coated with brilliant crystals and in cavities filled with white, limpid, barium sulphate accompanied by compact or acicular crystals of realgar. The average tenor of the debris resulting from the collapse of the mine workings is .003 to .004 per cent mercury.

The occurrence of native mercury in the alluvial material of the Huancavelica Valley is also described by Crosnier. Several times considerable quantities of mercury have been found at depths of 1 to 2 meters in the clay and gravel on which the town is built. In 1850 the curate of one of the parishes had a ditch dug near the town from the walls of which drops of mercury oozed out and collected in the bottom to a quantity of 6 quintals. On digging several meters from this trench mercury was still encountered. At the end of two weeks, after a total yield of nearly 40 quintals had been secured, the supply ceased entirely. About 1700 the same thing happened on a much larger scale within the town. The inhabitants, believing the entire soil of Huancavelica to be impregnated with mercury, began digging under the houses, and almost caused the collapse of the town. A satisfactory explanation of this occurrence, Crosnier says, is difficult in view of the facility with which mercury enters the smallest cracks in the soil and in rocks and penetrates to considerable depth. If the metal represents leakage from the furnaces at the mines, he thinks it strange that it has been able to descend so far from its course, and that it is not found at higher levels on the mountain where clay accumulates on the gentler slopes.

Hawley also confines his description to the ores in the sandstone. He says the Santa Barbara deposit is not a vein but a sandstone impregnated with ore with no well-defined walls. The quantity of mercurial sandstone is practically inexhaustible, but the grade is very low, the average being not over ½ per cent, and the richest portions rarely containing 2-½ per cent mercury. The general appearance of the ore is that of a common sandstone with very small particles of a bright-red color scattered through it. Some of it contains arsenical pyrite. Such ore runs richer in mercury. Realgar also occurs in considerable amount. Other minerals are barite closely mingled with siliceous grains and much pyrite.

Becker's brief account of the Santa Barbara mine is based on the observations of earlier authors. The deposit is an impregnation of cinnabar mainly in sandstone. Besides pyrite, the ore carries much arsenopyrite and realgar, differing in this respect from the other great cinnabar deposits of the world, though similar associations in smaller deposits are frequent. He cites Humboldt as authority for the statement that the arsenic occurs almost exclusively in the lower levels and for the mention of galena among the metallic minerals and calcite and barite as the gangue minerals.

Torrico y Mesa says the cinnabar is concentrated above all in the white sandstone, but it is also encountered in the limestone and shales in which a multitude of smaller mines have been worked. Accompanying the cinnabar in the sandstone, are fine-grained galena, realgar, arsenical pyrite, and barium sulphate.

In his description of the Santa Barbara mine, Arana follows Humboldt. He says it is enclosed in a bed of quartzose sandstone 400 m. thick. The entire bed does not carry cinnabar, but only certain layers and sometimes veinlets, so that the metalliferous mass rarely exceeds 60 to 70 m. Arana also refers to the ore in sandstone as a great vein usually 60 yards wide but with a range in width from 50 to 80 yards. As the vein narrows, the tenor increases. The mercury occurs in various forms—sometimes as a fine powder with a tenor of 4 to 30 per cent; sometimes in the rock itself like ruby silver; often as drops of pure mercury. Besides the cinnabar in sandstone, at Santa Barbara, he says it occurs at Silla Casa in veins cutting the limestone. The veins, which often consist of chalcedony, do not follow regular directions but cross and unite, forming pockets and shoots. During the last fifteen years of the nineteenth century all of the Huancavelica production came from these veins as the Santa Barbara mine had been idle because of its collapse.

Umlauff is the only writer who has attempted a detailed description of the Huancavelica ore deposits. He mentions the ocurrence of mercury in sandstone, limestone, limestone conglomerate, and the basalts west of Huancavelica. In the sandstone it occurs (1) in veinlets perpendicular to the stratification, (2) in isolated grains disseminated through it, and (3) in narrow compact masses consisting of cinnabar and the sandstone. It occurs in the limestone (1) in gash veins which follow the fractures of the rock and in which the cinnabar occurs with a crystalloid structure, (2) in small stockworks, (3) in lenticular masses disseminated in the rock, and (4) as a powder in cavities. In the conglomerates it is found (1) scattered throughout the rock and (2) in sedimentary veins filled with detrital products whose walls are formed by basaltic rocks. Fractures in the basalts contain metalliferous veins which carry mercury.

According to Umlauff, the localization of the cinnabar was determined by the porosity and structure of the country rock. Where the sandstone is porous, its entire mass is impregnated with cinnabar. On the contrary, the limestone, which is generally very compact, contains the cinnabar only in crevices and fractures and is not impregnated with it. The mineralizers seem to have followed the most accessible channels of circulation. In general these were in the sandstone. But where the sandstone was compact, or where the limestone offered open fractures, the mineralizing solutions utilized the limestone and deposited ore in it. The cinnabar in the conglomerate he considers in part of detrital origin derived from the sandstone and limestone and in part due to secondary infiltrations.

Another feature of interest described by Umlauff is the distribution of the cinnabar in the vicinity of the andesite inclusions which the sandstone and limestone enclose. Due to the uniformly compact texture of the andesite, the cinnabar rarely penetrated it and then only a very short distance. In some cases the andesite is surrounded by a rich corona of crystallized cinnabar of such open texture that it has been subsequently filled with clay. In other cases, the andesite is surrounded by compact sandstone that the cinnabar was unable to penetrate and beyond it is more porous sandstone richly impregnated with cinnabar.

Finally Umlauff mentions the occurrence of native mercury along the rivers of the region and their tributaries and in some of the underground workings. He thinks this has been derived through the action of atmospheric agents and meteoric waters on the cinnabar and accumulated with the detrital material, and through the desulphurization of cinnabar in contact with heated water vapor. Umlauff also discusses the tenor of the ore. He finds no change from the surface to a depth of 80 m. which was the lowest accessible depth. The average of samples taken from all the workings of the principal mines was 2 per cent mercury. This includes only the places where mineralization was actually visible and not the entire mass of sandstone and limestone. On the other hand, it should be borne in mind that the samples were taken from workings already exploited and nearly worked out. Analyses ranging from .50 to 10.10 per cent mercury are cited.

Dueñas' description of the mineralization is brief. At Santa Barbara he says the cinnabar impregnates the sandstone; at other places it forms thin sheets in fissures in the limestone; and it also occurs in the conglomerates. In addition to cinnabar and native mercury the sandstone is impregnated with galena, sphalerite, pyrite, and arsenopyrite, but in very small amount and in sporadic pockets.

Velarde says the cinnabar generally impregnates sandstone, but is also found in veinlets and fissures in the limestone, and occasionally in the conglomerates. Besides cinnabar and native mercury are small quantities of accessory minerals as galena, blende, pyrite, and arsenical minerals. The rich ores are irregularly distributed. The area of greatest mineralization, the vicinity of the Santa Barbara mine, is also where the andesite intrusions are most numerous and important. Recent assays of selected specimens showed 7 to 10 per cent mercury and the average of the ores being worked was .7 per cent mercury.

Strauss gives a short account of the mode of occurrence and mineralogy of the ores. The cinnabar impregnated the sandstone, occurring sometimes in bunches in it, and also filled small fractures and cavities in the limestone and less frequently in the conglomerate. It sometimes occurs as a powder bespattering the rock. The principal distribution of the cinnabar is in the sandstone in which it occurs in minute cavities between the grains. In the limestone it follows the joint planes or cleavage or is deposited on the walls of the cavities. The andesite, which occurs in masses of irregular size through the sedimentary rocks, is barren of cinnabar. Mercury-bearing sandstone or limestone frequently surrounds these masses, which, on account of their imperviousness, blocked the passage of the mineral solutions, thereby causing deposition. Associated with the cinnabar and the native mercury are galena, blende, pyrite, arsenopyrite, and realgar in small amounts. Picked samples of the ore run up 10 per cent mercury.

According to Gerth the mercury occurs chiefly as cinnabar irregularly distributed in coarse-grained, porous sandstone in association with other sulphide ores as arsenopyrite and galena. The mineralization extends, however, into the neighboring limestone and limestone breccias in cracks and veinlets.

Observations by Williams Expedition.—Owing to the collapse that the principal workings suffered and the long period of idleness the mines have passed through, the Huancavelica mines are almost completely inaccessible. Only a small part of the workings immediately below the outcrop in the vicinity of the Brocal were traversable and these are located entirely within the sandstone. The great openings of the Botija Puncu mine as viewed from the surface give some idea of the nature of that occurrence, though no ore was seen about them. The surface workings of the Trinidad and Florida mines are in the Conglomerate limestones, but all vestiges of ore have been removed and there is little evidence to show the mode of occurrence.

The maximum ore deposition took place within the Grand Farallón sandstone in the vicinity of the south end of its outcrop. The typical Grand Farallón sandstone is a light yellow to white quartz sandstone consisting of well-rounded grains cemented with a siliceous matrix. The sand grains range from ¼ mm. to ½ mm. in diameter. There is more or less variation in the coarseness of the texture of the rock, some of it being made up largely of grains ranging between ¼ mm. to ⅓ mm. in diameter and some consisting for the most part of grains larger than ⅓ mm. The degree of induration also varies greatly. Some of the rock is hard and compact, but much of it is quite friable and can be rubbed to a loose sand with the hand.

In the mineralized part of the sandstone, the siliceous matrix is replaced wholly or in part by the ore minerals. In the richer ores the sand grains themselves have been attacked and replaced by the ore-bearing solutions or penetrated by them. The most abundant ore mineral is pyrite which frequently has completely replaced the original cementing material. Next in abundance is the cinnabar. There is also some fine-grained galena and here and there a little realgar. Much of the ore is associated with a black or dark bituminous substance that imparts a dark stain to the otherwise light-colored sandstone.

The chief mode of occurrence of the ore minerals is as an impregnation of the sandstone. The impregnation may be uniform throughout a large mass of the rock or concentrated along certain planes giving the mineralized rock a banded appearance. The ore also penetrates the rock in irregular veinlets and stringers. The nature of the mineralization has been determined by the texture of the immediate country rock, whether it is uniformly porous or not and whether it has been fractured or not. In some places the cinnabar has been deposited alone, but more commonly it is associated with the other sulphides and the bituminous matter.

The preceding description of the ore in the sandstone is based on the lean ore seen in the pillars in the limited accessible parts of the Santa Barbara mine workings near the surface at the Brocal and ore that is in the dumps around the Brocal. No observations can now be made concerning the larger features of the shape and size of the ore bodies and the distribution and position of ore shoots. Though the locus of the ore is the Grand Farallón sandstone, it is not by any means coextensive with that sandstone. The description of the ore makes clear what were the factors that determined its distribution. The actual distribution is not now determinable.

Still less are the observations that can be marshalled for a description of the ore in the limestone. The compact nature of the limestone makes it probable that ore deposition in it was confined to fractures and openings. As a result of the tilting, folding, and faulting the limestones have been subjected to, there has been slipping along the bedding planes and jointing and fracturing across those planes. The nature of the old workings, as well exemplified in the Botija Puncu mine, suggests that the ore was deposited along the planes of these openings, an inference in harmony with the descriptions of previous writers. Though of far less importance than the ore in the sandstone, this type of ore yielded much mercury,, if one can judge by the extent of the work that has been done in the limestone.

Umlauff considers the occurrence of the ore in the conglomerate as accumulations of cinnabar derived from the mineralized sandstone and limestone. Although none of the ore was seen, the authors regard this view as highly improbable. In the first place, though but little idea can now be gotten concerning the relations of these ore bodies to the enclosing rock and to the other modes of occurrence, that little evidence is against such an interpretation. The position of the ore bodies seems to have been vertical and their location is in the midst of the main mineralized area, indicating a mineralization by the same ascending solutions that caused the rest of the mineralization. But decisive evidence against that interpretation, if our conception of the geologic history of the district is correct, is the fact that the mineralization was subsequent to the igneous activity, and the latter was subsequent to the formation of the conglomerate. Hence the ore in the conglomerate was formed by the same agents and at the same time as the rest of the ore. The probability is that its mode of occurrence was largely as an impregnation and replacement of the matrix of the conglomerate outward from planes of jointing and fracturing.

None of the ore occurrences in the igneous rocks were examined. Workings in the trachyte on the west side of the Sascamarca Quebrada below the mouth of the Quebrada de Santa Barbara are visible from the trail to the Belén tunnel. The ore occurrences in the igneous rocks have been of the least importance economically. Their chief point of interest is that they fix the period of mineralization subsequent to the igneous intrusions.

Genesis of the deposits.—The literature on the Peruvian mercury occurrences is surprisingly lacking in expressions of opinion or discussions of the origin of the deposits.

Crosnier says a superficial study of the deposits at Huancavelica shows they have nothing in common with veins. Everything indicates that the easily volatile mercury was introduced in the form of vapor into the sandstone and shale during the uplift which turned the strata on end. This explains why the cinnabar is more or less concentrated at certain points and forms irregular veinlets of pure cinnabar, sometimes with laminated structure and sometimes in isolated crystals, and why one encounters in the deeper parts of the Santa Barbara works numerous geodes filled with crystallized barium sulphate and irregular veins of massive and crystalline realgar. Sulphurous and arsenical vapor he thinks reacted on the iron oxide contained in the sandstone and formed the arsenopyrite with which it is so frequently impregnated.

Strauss considers the ore undoubtedly due to thermal action. He cites the occurrence of the thermal springs close to the town which have a temperature of 82 degrees F. and which emit a sulphurous odor and deposit calcium carbonate and oxide of iron. He regards the intrusion of the basalt as the cause for the circulation of the thermal solutions which produced the ore and the springs. The sandstone formed a channel for the passage of the solutions, and from if they extended to the limestones. The cinnabar may have been precipitated from solution by reduction of pressure and temperature in its upward course, or through chemical action by oxidation of the H_2S gases and the reactions of the alkaline salts in warm, diluted solutions. The native mercury is probably the result of the chemical activity of acid waters upon the cinnabar.

Gerth remarks that he could not observe an immediate connection between the mineralization and the countless intrusions of andesitic and basaltic rocks that occur in the neighborhood. It is another example, he says, of the fact that mineral solutions in porous sandstones spread irregularly over wide extent and their source is difficult to point out.

Mercury deposits the world over constitute a fairly compact type. They are almost always associated with volcanic rocks of Tertiary or Recent age. They were formed near the surface, and hot springs are frequent in many quicksilver districts. A scant association of minerals is a further characteristic. From the preceding account it is clear that the Huancavelica deposits conform to these traits. The mineralization took place subsequent to the extrusion of the igneous rocks, as the latter have themselves been mineralized. Their age is probably Miocene. Hence the mineralization is not older than Miocene and may be younger. Whether the present warm springs at Huancavelica come from the same source as the solutions that deposited the mercury is a question concerning which there is no definite evidence. Those waters do not now deposit mercury at their vents. It is entirely within the realm of probability, however, that they represent the last phase of the cycle of volcanic activity, of which the beginning is represented by the volcanic rocks of the district, and of which the mercury deposits constitute an intermediate stage.

IV. THE CRETACEOUS FAUNA OF HUANCAVELICA.

The Cretaceous faunas of the Andean geosyncline are, without known exceptions, of the massive limestone type that has long since come to be known in Europe as the Urgonian facies—irrespective of any age implications; or what from an occidental point of view would be called a Comanchean facies. That is to say, they represent a clear-water fauna characteristic of the Mediterranean regions of the world, in somewhat striking contrast to the contemporaneous littoral faunas that flourished in the waters lying to the north and south of the Mediterranean, where greater or less amounts of clastic sediments resulted in sandstones, shales, and impure limestones. With scarcely an exception from Venezuela to Bolivia the mollusca of these faunas are in the form of casts[1] and the nature of the remains has resulted in much uncertainty and many errors of identification. Some of this will always be present but the only hope for a better understanding of these faunas rests on the amassing of much larger collections and perhaps the fortunate discovery of better preserved and more varied representations in some marly lentil or band.

It is obvious that despite the rather formidable literature we know almost nothing of the Cretaceous of this vast area.

The collection from Huancavelica is as large or perhaps larger than any heretofore made from a single outcrop, only one specimen recorded in the following pages (*Schloenbachia* sp.) having come from a different outcrop. In view of the somewhat discordant assemblages of organisms recorded from the Cretaceous of Peru by Steinmann and his collaborators, this must be considered a merit, since there can be no question of misunderstanding of the stratigraphic relations, or of the mixing of forms from the different horizons, at Huancavelica.

The specimens found at Huancavelica are nearly all more or less unsatisfactory casts. If they had come from the United States it is doubtful if they would be worth the amount of time required to elaborate them. Coming, as they do, from a most inaccessible region in association with a world-celebrated ore deposit they fully merit the attention that has been given them and the trying labor spent in their collection. The treatment has been conservative throughout, as the large number of specifically unnamed forms attests, and the doubtful name of an old-world species has been accepted if a Huancavelica form was identical with one masquerading under such a name in the literature of the Peruvian Cretaceous.

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[1] There are exceptions to this statement in collections from Colombia.

The only previous reference to fossils from Huancavelica is by Dueñas[1] who in 1908 listed the following from the vicinity of Huancavelica:[2]

Holectypus Paulckei Bravo
Enallaster cf. peruvianus Gabb
Hemiaster australis Gabb
Pygurus sp.
Pecten quinquecostatus Sowerby

These were unquestionably from the same horizon as our collection. Lisson[3] records *Vola alata* von Buch, a Liassic species; and *Stephanoceras* aff. *Vavley* Oppel, and *Pleurotomaria* cf. *subfasciata* d'Orbigny from the Oolitic of Santa Barbara. Whether this refers to the little mining town of Santa Barbara on the Huancavelica mountain or what it may mean is not clear.

The present contribution enumerates 39 forms, representing 28 genera in 25 families, and there are in the collections 3 additional undeterminable Gastropods and 8 additional undeterminable Pelecypods. These 39 species comprise 4

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[1] Dueñas, E. I., Bol. Cuerpo Ing. d. Minas del Peru, No. 62, p. 154, 1908.

[2] In an account of a trip through this region Gerth (Gerth, H., Geol. Remdschau, Bd. 6, p. 144, 1915) speaks of marly beds on the west side of Huancavelica which contained "the characteristic Aptian fauna of Peru." His specimens were lost in transit but are undoubtedly the same as those described in this paper. Whether he was justified in calling them Aptian, the reader can judge.

[3] Lisson, C. I., Edad de los Fósiles Peruanos, pp. 28, 30, 1917.

Echinoids and 35 Mollusca; and the latter include 2 Cephalopods, 8 Gastropods, and 25 Pelecypods. The Pelecypods include 10 referred to the Teleodesmacea, one to the Anomalodesmacea and 14 to the Prionodesmacea. The largest families are the Ostreidæ with 5 species; the Pectinidæ with 3 species; and the Tellinidæ with 3 species. No other families have more than two species. The fauna is essentially a very shallow, clear-water assemblage. It is chiefly remarkable for the paucity of Ammonites and the absence of Belemnites, Rudistids, and sharks teeth. There are no Brachiopods and, among the Mollusca, no Arcas, Trigonias, or Aporrhaidæ. In view of its limited extent an extensive analysis is unwarranted, since it would be based so largely on negative evidence. The fauna is clearly Atlantic in its facies and shows considerable resemblance to the so-called Comanchean faunas of Texas and Mexico. It is still more strikingly similar to the Upper Cretaceous faunas of northwestern Africa and the Iberian peninsula. It has some points of contact with the Upper Cretaceous faunas of southern India, but nothing suggestive of the Cretaceous faunas of the Western Interior or the Pacific coast of North America.

The age of the Huancavelica fauna is a question of greatest interest. Much has been written on the Cretaceous of Peru, and the praiseworthy pioneer work of Professor Steinmann and his associates is admirably reflected in the lists compiled by Lisson, and already referred to, where however the Peruvian fossils are listed under the European étages, with an appearance of finality of age determination that certainly has no basis in fact. The Huancavelica fauna is assembled in the accompanying table in which is given the outside range of the forms and their ocurrence in Peru in beds which Professor Steinman has determined as Aptian, Albian, Cenomanian, and Emscherian. It will be seen that we have in a single outrop at a single geological horizon, an assemblage of which 5 forms have been previously recorded from the "Aptian" of Peru; 6 from the "Albian" of Peru; 6 from the "Cenomanian" of Peru; and 9 from the "Emscherian" of Peru. It must be obvious that these singular ranges do not mean long-lived species, ranging from the middle of the Lower to the middle of the Upper Cretaceous, but do mean that the age determinations are extremely unreliable. It is probable that the Huancavelica fossiliferous horizon is contemporaneous with the widest extent of the Upper Cretaceous sea in the Andean geosyncline, and with the southward extension of the red gypsiferous Cretaceous in Bolivia, as the Huancavelica *Cyphosoma* occurs at Miraflores near Potosí in Bolivia. This is collateral evidence of its Emscherian age. Moreover, the identity of species with forms described by Brüggen from Peru is an argument in the same direction, although, as was pointed out above, not an especially weighty one. The resemblances to the Upper Cretaceous faunas of Algiers and Tunis appear to be especially well marked, and these tend to make the deposits seem slightly older than Emscherian. It must be admitted that in such a little-known region the previous method of categorical conclusions goes beyond the evidence and until such time when a measured fossiliferous section is available as a foundation, exact age determinations outrun the facts. As an instance Douglas has recently suggested[1] that in Steinmann's section along the Oroya Railroad the so-called Albian and Cenomanian are reversed. It is preferred then to limit the conclusion as to the age of the Huancavelica fauna to the statement that it is unquestionably of Upper Cretaceous age, and if it be permitted to express an opinion (as an opinion and not a conclusion) to incline toward upper Turonian or lower Emscherian as the most probable age.

However this may be, the endeavor has been to bring together as many facts as could be gotten on this fauna with the hope that the following pages will prove useful to whoever may have the privilege of some day working with large and carefully-made collections from this most interesting region.

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[1] Douglas, J. A. Quart. Jour. Geol. Soc. Lond., vol. 77, p. 271, 1921.

HUANCAVELICA	Peruvian Horizons According to Steinmann				*Range in other countries or most closely related species and its range*
	Aptian	Albian	Cenomanian	Emscherian	
Cyphosoma peruanum				X	C. volanum Cragin of Washita.
Holectypus Paulckei		X			H. serialis Desh. of Emscherian and H. planatus Roemer of the Comanchean.
Botriopygus compressus	X				
Enallaster peruanus	X	X	X		E. lepidus de Loriol of the E. texanus (Roemer) of the Comanchean.
Cucullaea maresoteutobochus				X	Santonian of N. W. Africa.
Pinna decussata				X	Turonian to Senonian.
Ostrea Boucheroni			X		Cenomanian of N. W. Africa.
Exogyra pseudoafricana			X		Cenomanian of N. W. Africa.
Exogyra minos	X				Lower Cretaceous of Europe.
Exogyra Reissi			X		E. conica (Sowerby) E. arduennensis (d'Orb.)
Pecten æquicostatus			X		Cenomanian of Europe.
Pecten quinquecostatus	X			X	Upper Cretaceous of North America and Europe.
Anomia peruana	X	X			
Pholadomya elliptica		X			P. elliptica Münst. Cenomanian to Senonian.
Crassatellites caudata		X			C. Picteti Coquand of Cenomanian of N. W. Africa.
Cardita Doumeti			X		Cenomanian of N. W. Africa.
Cardium pulchrum				X	
Tellina scitulina				X	Arrialoor group of India.
Tellina inconspicua				X	Trichinopoly group of India
Nerinea c.f. espaillaciana					Cenomanian.
Turritella vibrayeana		X			Albian.
Natica singularis				X	N. Gervaisi Coquand.
Placenticeras syrtale				X	Turonian to Senonian.

SYSTEMATIC LIST OF THE FAUNA.

- Echinoidea
  - Phymosomatidae
    - Cyphosoma peruanum Brüggen
  - Pygasteridæ
    - Holectypus Paulckei Bravo
  - Echiconeidæ
    - Botriogypus compressus Gabb
  - Spatangidæ
    - Enallaster peruanus Gabb
- Mollusca-Pelecypoda-Prionodesmacea
  - Nuculidæ
    - Nucula sp.
  - Parallelodontidæ
    - Cucullaea maresoteutobochus (Coquand)?
  - Pinnidæ
    - Pinna decussata Goldfuss?
  - Pernidæ
    - Inoceramus c.f. cripsi Mantell
    - Inoceramus Lissoni Berry
  - Ostreidæ
    - Ostrea Boucheroni Coquand
    - Exogyra pseudoafricana Choffat
    - Exogyra maroimensis (White)
    - Exogyra minos Coquand?
    - Exogyra Reissi Paulcke
  - Pectenidæ
    - Pecten æquicostatus Lamarck?
    - Pecten quinquecostatus Sowerby.
    - Pecten sp.
  - Anomidæ
    - Anomia peruana Gabb
- Anomalodesmacea
  - Pholadomyidæ
    - Pholadomya ellipticaformis Berry
- Teleodesmacea
  - Crassatellitidæ
    - Crassatellites caudata Gabb
    - Astartidæ
    - Astarte sp.
  - Carditidæ
    - Cardita Doumeti Thomas & Peron
    - Cardita huancavelicensis Berry

- Lucinidæ
    - Lucina sp.
- Cyprinidæ
    - Cyprina (?) sp.
- Carditidæ
    - Cardium pulchrum Brüggen
- Tellinidæ
    - Tellina scitulina Stoliczka
    - Tellina inconspicua (Sowerby)
    - Tellina sp.

- Gastropoda
    - Nerineidæ
        - Nerinea c.f. espaillaciana d'Orbigny
    - Turritellidæ
        - Turritella vibrayeana d'Orbigny ?
        - Turritella sp.
    - Naticidæ
        - Natica Gastelumendi Berry
        - Natica singularis Möricke
        - Tylostoma sp.
    - Fulguridæ
        - Pyrifusus sp.
    - Volutidæ
        - Liopeplum (?) sp.
- Cephalopoda
    - Prionotropidæ
        - Schloenbachia sp.
    - Cosmoceratidæ
        - Placenticeras syrtale (Morton)

ECHINODERMA

Class ECHINOIDEA

Subclass REGULARIA ECTOBRANCHIATA

Suborder STIRODONTA

Family PHYMOSOMATIDÆ

Genus CYPHOSOMA Agassiz

Cyphosoma peruanum Brüggen

PLATE VII, Figs. 1-6.

Cyphosoma peruanum Brüggen, Neues Jahrb., Beil. Bd. 30, p. 767, pl. 26, figs. 5-5c, 1910.

There are four specimens of this species from Huancavelica ranging in size from a diameter of 1 centimeter to

2.6 centimeters. The imperforate primary tubercles and compound ambulacral plates indicate their reference to this genus, and I cannot distinguish them from this species, described by Brüggen from beds of supposed lower Senonian age at Huanyamba (Huañambra, according to Lisson), Department of Cajamarca. The form is depressed with interambulacra nearly twice as wide as the ambulacra, maximum width 6 mm. in one and 10 mm. in other, each with two rows of primary tubercles. The ambulacral plates are relatively low and wide, with usually 2, but sometimes 3 secondary tubercles; and consist usually of two primaries and a demiplate. The pore pairs are crowded at the peristome, where there has obviously been resorbtion. Pored areas somewhat undulating.

The gross appearance of this small species is well shown in Brüggen's figures of the type. Merely the outlines of a large and small specimen from Huancavelica have been indicated but figures of the ambulacral area near the peristome and in the ambital region are given.

The only other positively known occurrence of this species is at Miraflores near Potosi, Bolivia, where many specimens were collected by the Williams Expedition. It is probable, however, that this species is widely spread in the Peruvian Cretaceous, since there are a large number of supposed species of Cyphosoma recorded from Peru, some of which may represent this species. An enumeration of these is worth publishing. They are:

Cyphosoma Pinzosi Brüggen. Neues Jahrb., Beil. Bd. 30, p. 768, pl. 27, figs. 1-1c, 1910.

C. Schlagintweiti Brüggen, Idem, p. 766, pl. 26, figs. 4-4c, from Otusco.

C. Joudi Cotteau. Brüggen, Idem, p. 765. From Pastos de Lachoj and Shagapayana (A North African Campanian species).

C. cf. *Archiaci* Cotteau. Brüggen, Idem, p. 765, from Huañambra (A French Santonian species).

C. major Coquand, Brñggen, Idem, p. 766, from between Yanacancha and La Tahona (A North African Turonian species).

C. sp., Brüggen, Idem, p. 766 from Shagapayana and Santa Clara.

The genus is not nearly so common in the North American

Cretaceous as it is in that of southern Europe, northern Africa, and western South America, the following 3 North American species all being confined to the Comanchean (Mediterranean) Cretaceous: *C. hilli* Clark from Austin Chalk of Texas; *C. texanum* Roemer from the Fredericksburg group of Texas, and recorded from the Cretaceous of California and Orizaba, Mexico; and *C. volanum* Cragin from the Washita group of Texas. This last is significantly close to *Cyphosoma peruanum*.

Subclass IRREGULARIA
Order GNATHOSTOMATA
Suborder HOLECTYPINA
Family PYGASTERIDÆ
Genus HOLECTYPUS Desor
Holectypus Paulckei Bravo

Holectypus Paulckei Bravo, Bol. Cuerpo Ing. d. Minas del Peru, No. 25, p. 97, pl. 1, figs. 1-8, 1905.

Dueñas, Idem, No. 62, p. 154, 1908.

Holectypus cf. *serialis* Deshayes. Paulcke, Neues Jahrb., Beil. Bd. 17, p. 260, pl. 16, figs. 3, 3a, 1903.

Holectypus sp. n. sp. Salfeld in Hauthal, Wiss. Ver. Gesell. Erdkunde, Leipzig, Bd. 7, p. 219, pl. 4, fig. 1, 1911.

? *Discoidea numismalis* Gabb, Jour. Acad. Nat. Sci. Phila., 2d ser., vol. 8, p. 300, pl. 43, figs. 3-3b, 1876, Pflucker and Rico, p. 21.

Gabb's work is so notoriously inaccurate that there is a strong probability that the last named citation, representing a form collected by Raimondi at the Hacienda Yauca, 7 km. from Queropalca, Province of Huamalis, may represent this species, although his figure is a distictly more depressed form, with a slightly more posterior periproct, and conical apical system. Because of this uncertainty and the resulting change of the name should the two prove to be identical, this possibility of identity is ignored since Bravo's name is based on accurately described and figured material. The collection includes 7 specimens from Huancavelica that are identical with Bravo's type material. The forms which Paulcke compared with *Holectypus serialis* Deshayes, an

Emscherian species of Europe, Algiers, and Palestine, are identical with it as is also the unnamed species recorded by Salfeld.

The species is recorded from the following Peruvian localities:

Quebrada Celcas near Utucubamba, La Lucha or Guai-Guai, Cajamarca, Cospán, Asunción, Hacienda Montón and Hacienda Hualanga, Hacienda Quiulla, Huallanca (Dept. of Huánuco), Hacienda Colpa (Cajatambo), Sillipata, Province Huarochiri.

The species is very close to *Holectypus planatus* Roemer,[1] a common form in the Trinity, Fredericksburg, and Washita divisions of the Cretaceous of Texas; to *Holectypus Castilloi* described by Cotteau[2] from the Cretaceous of Mexico; and to *Holectypus pennanus* White[3] from the Cretaceous of Sergipe, Brazil.[4]

The very large amount of *Holectypus planatus* Roemer studied by the late Wm. Bullock Clark show that species to have been exceedingly variable and in the absence of transitional forms would be considered to represent several species. This would prove probably also to be the case with the South American forms if only more material was available.

Douglas[5] considers this form, which he refers to the Cenomanian, as identical with the Texas species.

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[1] Clark, W. B., U. S. Geol. Survey Mon. 54, p. 65, pl. 25, figs. 2-4; pl. 26, figs. 1-1e, 1915.

[2] Cotteau, G., Sur les Echinides crétacés du Mexique, Compt. Rendus, tome 110, 24 Mai, 1890.

[3] White, C. A. Archiv. Mus. nac. Rio de Janeiro, vol. 7, p. 256, pl. 27, figs. 18-20. 1888.

[4] The following two references of something very similar should be cited:

Holectypus planatus var *numismalis* Gabb. Sommermeier, Neues Jahrb. Beil Bd. 36, p. 394, pl. 15, figs. 1-3, 1913.

Holectypus numismalis Paulcke, Neues Jahrb. Beil. Bd, 17, p. 261, 1903.

[5] Douglas, J. A., Quart Jour. Geol. Soc. Lond., vol. 77, p. 272, 1921.

Order ATELOSTOMATA
Suborder C. SPATANGINA Jackson
Tribe A. CASSIDULOIDEA
Family ECHINANEIDÆ
Genus BOTRIOPYGUS d'Orbigny
Botriopygus compressus Gabb

PLATE VII—Fig. 7-12.

Botriopygus compressus Gabb, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. 8, p. 300, pl. 43, figs. 2, 2a.

This species was very imperfectly characterized by Gabb from specimens collected by Raimondi near Calca, south of Chackapoyas in the Department of Cuzco. There are two broken specimens in the Huancavelica collection which add considerable to our knowledge of this form. Test compressed, slightly concave actinially, rather evenly rounded abactinically, slightly higher behind the middle. Ambital outline subcircular to shortly elliptical, slightly flattened in the interambulacra. Apical system and mouth slightly in front of the center. Periproct elliptical, on the actinial side of the posterior margin. Petals subequal, flush, not closing, becoming obsolete below the ambitus, the pores becoming distinct as the margin is passed and the ambulacral plates here being very low and wide, each with a single pore pair; these pore pairs are biserial by the regular alternation of marginal and central positions. Ambulacral plates in the subequal petaloid areas low, smooth, the inner of the pores of each pair prominent, subcircular, the outer starting as pores in the apical region rapidly pass to long slit-like sulcations. Actinial surface of the interambulacra covered with numerous small low tubercles. Abactinial surface not well preserved, apparently almost smooth. The two specimens from Huancavelica, shown in outline in the accompanying figures, have the following dimensions:

Length 4.9 cm., 6.9 cm.
Width 4.1 cm., 6.2 cm.
Height 16.5 mm., 22.5 mm.

The character of the pore pairs in the petaloid part and in the peristomal portion of the ambulacra are also illustrated.

Gabb described a second species of Botriopygus, namely *B. elevatus,* from Peru. This came from 10 km. of Cajamarca in the Province and Department of that name. This is a somewhat smaller and considerably more elevated form, and is closely related to *Botriopygus alabamensis* Clark[1] of the Ripley formation of Alabama. The genus is rare in North Ameria but may prove to be common in the Andean Cretaceous. Lisson records undetermined species of Botriopygus from Ventanilla, Province of Yauli, and Luya, Province of Luya, in the Department of Lima, and considers them as well as Gabb's two species as of Aptian age.

Tribe B. SPATANGOIDEA
Family SPATANGIDÆ
Genus ENALLASTER d'Orbigny
Enallaster peruanus Gabb

PLATE VI—Figs. 1-11.

Ennalaster peruanus Gabb, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. 8, p. 301, pl. 43, figs. 4-4c, 1876.

Enallaster of *peruanus* Bravo, Bol. Cuerpo Ing. d. Minas Peru, No. 25, p. 104, 1905.

? *Enallaster* aff. *lepidus* de Loriol. Neumann, Neues Jahrb. Beil Bd. 24, p. 94, 1907.

Toxaster texanus Salfeld in Hauthal, Eeisen. Wiss. Verh. Gesell. Erdkunde Leipzig, Bd. 7, p. 218, pl. 4, fig. 2, 1911.

Enallaster texanus Sommermeier, Neues Jahrb., Beil Bd. 36, p. 396, pl. 15, figs. 4-11, 1913.

Enallaster cf. *peruanus* Pflücker and Rico, Anales de Construcciones Civiles de Minas del Peru, tomo 3, 1883; Dueñas, Bol. Cuerpo Ing. d. Minas, Peru, No. 62, p. 154, 1908.

Enallaster texanus Lisson, Edad. Fos. Feruanus, pp. 41-47, 1917.

? *Hemiaster steinmanni* Neumann, Neues Jahrb., Beil. Bd. 24, p. 95, tf. 1, pl. 3, figs. 5-5f, 1907.

? *Enallaster Kartsteni* de Loriol, Mem. soc. phys. et hist. nat Geneve, vol. 24, 1876; Karsten, Geol. de l'ancienne Colombie, Bolwarienne Venezuela, Nouvelle Grenade et Ecuador, pp. 6, 18, 1886.

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[1] Clark, W. B., U. S. Geol. Survey Mon. 54, p. 68, pl. 24, figs. 2-2f. 1915

? ***Spatangus columbianus*** Lea, Amer. Phil. Soc. Trans., 2d ser., vol. 7, p. 257, pl. 9, fig. 11, 1841.

The type of this species, which was described by Gabb, was collected by Raimondi near Ollon, 2 leagues from Cajamarca in the Department of Cajamarca. Gabb noted its resemblance to *Enallaster texanus* (Roemer) but pointed out that "it is less markedly pentagonal, more narrowed behind and differs in the shape of both of the apertures." We collected 50 specimens at Huancavelica and these range in size from a length of 12 mm. to a length of 4 cm. They have been compared with many specimens of *Enallaster texanus* (Roemer) from the Texas Cretaceous determined by the late Wm. Bullock Clark. The Peruvian form differs from that species in the following particulars: The form is more depressed and this is especially emphasized in small specimens; the ambital outline is less pentagonal and more rounded; the anterior ambulacrum is less impressed; the lateral anterior ambulacra are simple curves and do not show the tendency toward a sigmoid curve; the posterior petals are slightly longer; the posterior interambulacrum is less truncated and more rounded; the anus is not quite so high in position; according to Bravo (op. cit.) the pore arrangement differs, but this appears to us to be a variable feature; in the apical system the right anterior genital is not produced backward, and the left posterior genital occludes the left posterior ocular, and both of the posterior oculars are larger. The constancy of these last named features is not certain as the apical system is indifferently preserved in most specimens, but it appears to be consistently longer than in *Enallaster texanus.*

Enallaster texanus is very common in the Trinity, Fredericksburg, and Washita groups of the Cretaceous of Texas and New Mexico, and has been recorded by Böse[1] from the so-called Vraconian of the State of Chihuahua, Mexico. It is recognized to be closely related to the Old World

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[1] Böse, E. Inst. geol. Méx. Bol. 25, p. 166, pl. 40, figs. 6-10; pl. 41, figs. 2-4; pl. 42, fig. 1, 1910.

Enallaster lepidus de Loriol. Two other species are recorded from the Mexican Cretaceous, namely: *Enallaster mexicanus* Cotteau and *Enallaster bravoensis* Böse; and *Enallaster böhmi* de Loriol is recorded from Honduras.

Enallaster peruanus, or what is believed to represent it, is recorded from a great many localities in the Peruvian Cretaceous from beds to which ages ranging from Aptian to Cenomanian have been assigned.

It remains to notice several occurrences under various names that may also represent this species. The single specimen which Lea described from the mountains between Tocaima and La Messa in Colombia as *Spatangus columbianus* is obviously an Enallaster and may be this species. von Buch considered these beds Upper Cretaceous but Humboldt and Lea regarded them as Middle Jurassic. Possibly representing this species also is de Loriol's *Enallasster Karsteni* collected by Karsten from Barbacoas, Venezuela. The form from Caracoles, Bolivia, from a supposed older Mesozoic horizon which Steinman called? *Heteraster lorioli*[1] also suggests this species, although I have not included it in the foregoing synonymy. Finally there is *Hemiaster steinmanni* described by Neumann from Huallauca, Department of Huánuco, and from near Parobamba, Department of Ancachs, from beds referred to the Rotomagian, although, according to Schlagintweit[2] the outcrop at Huallanca is of Senonian age and the material is identical with the associated specimens which Neumann identified as *Enallaster* cf. *lepidus* de Loriol. Schlagintweit is probably correct in his observation although Neumann's figures show a peripetalous fasciole characteristic of Hemiaster, but this may, of course, have been imaginary.

Douglas[3] considers that *Enallaster peruanus,* which he refers to the Cenomanian, as probably identical with *E. texanus* (Roemer).

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[1] Steinmann, G., Neues Jahrb., Beil. Bd. 1, p. 250. tf. 213, pl. 14, fig 5, 1881

[2] Schlagintweit, O., Neues. Jahrb., Beil. Bd. 33, p. 52, 1912.

[3] Douglas, J. A., Quart. Jour. Geol. Soc. Lond., vol. 77, p. 272, 1921.

Enallaster peruanus is recorded from the following localities:

Huancavelica, Department of Huancavelica

Utcubamba, Province of Luya, Department of Amazonas.

Parobamba, Department of Ancachs

Hacienda Utchupata, Province of Huari, Department of Ancachs

Near Oyón, Province of Cajatambo, Department of Ancachs

Between Huaninga and Rocropa, Province of Huaras, Department of Ancachs

Cajabamba, Pampa Culebra, Province of Cajabamba, Department of Cajamarca

Pilancones, Province of Hualgayoc, Department of Cajamarca

Cochamarca, Hacienda Calluan (El Montón), Department of Cajamarca

Huananbamba and Celendín, Department of Cajamarca

Huallanca and Margos, Department of Huánuco

Near Tarma, Province of Tarma, Department Junín

Sincamachay, Province of Yauli, Department of Junín

Llocllapampa, Province of Jauja, Department of Junín

Baños: Atavillos Altos, Province Canta, Department of Lima and according to Sommermeier (1913) Romeral, Tambo Lluy, Between Pomacocha and Lluy, Curgos, Cashapuyre, Aguamiro, Pariahuanca.

MOLLUSCA

Class PELECYPODA

Order PRIONODESMACEA

Family NUCULIDÆ

Genus NUCULA Lamarck

Nucula sp.

Two specimens, each with both valves, from Huancavelica, with the following dimensions:

Length 10 mm., 16 mm.
Height 10 mm., 13 mm.
Width 6 mm., 7.5 mm.

The form is somewhat inflated, triangular in outline, with rounded margins, except the anterior umbonal margin which is straighter. Surface marked by fine concentric growth lines and fine radial sulcæ.

This is probably a new species, whose description must await the collection of additional material. It shows some resemblance to *Nucula bidorsata* Stoliczka[1] of the Ootatoor group of southern India. It is larger and much less elongated than *Nucula peruana* Gabb[2] collected by Raimondi near Tingo, Province of Huari, Department of Huaraz. The only other Nuculas known from the Peruvian Cretaceous are *Nucula* sp. Gabb from Ollon and *Nucula* sp. Bravo from Pachacayo, Department of Junín.

Family PARALLELODONTIDÆ

Genus CUCULLÆA Lamarck

Cucullæa mareso-teutobochus (Coquand) (?)

Arca mareso-teutobochus Neumann, Neues Jahrb. Beil. Bd. 24, p. 109, pl. 5, figs. 1, 1a, 1907.

Cucullaea mareso-teutobochus Brüggen, Idem, Bd. 30, p. 754, 1910.

A single specimen from Huancavelica is identical with a similarly undeterminable internal cast from the pass of Charata between Oroya and Tarma, Department of Junín, to which Neumann gives the above name, identifying it with Coquand's species from the Santonian of Algiers and Tunis. It may, of course, be that species, but certainly presents no characters justifying such an identification. This species has also been identified by Brüggen from Otusco, Department of Cajamarca; and San Pedro, Department of Ancachs.

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[1] Stoliczka, F., Pal. Indica Cret. Faunas S. India, vol. 3, p. 329, pl. 17, figs. 24-27, 1871.

[2] Gabb, W. M., Jour. Acad. Nat. Sci., Phila., 2d ser., vol. 8, p. 292, pl. 41, fig. ii (not fig. 1 as stated in the text), 1877.

Family PINNIDÆ

Genus PINNA Linné

Pinna decussata Goldfuss (?)

PLATE VIII—Fig. 1.

Pinna decussata Brüggen, Neues Jahrb. Beil. Bd. 30, p. 753, 1910.

This well known European species, the types of which came from the Quader of Haltern (Westphalia) and Schandau (Saxony), was identified by Brüggen in a single specimen from Pastos de Lachoj, near Hullauca, Department of Huánuco, from beds considered to be Emscherian in age. Rather numerous fragments of what appears to be the same form were obtained at Huancavelica. The best of these is shown in the accompanying figure, and although it probably represents a new species, the material is entirely inadequate for characterization. The European *Pinna decussata,* which it resembles, is somewhat fully discussed by Woods.[1] It is common in the English chalk, ranging from the zone of *Schloenbachia varians* to that of *Ostrea lunata,* i.e., from middle Turonian to upper Senonian.

Family PERNIIDÆ

Genus INOCERAMUS Parkinson

Inoceramus cf. *cripsii* Mantell

PLATE VIII—Figs. 3-5.

There are numerous fragmentary casts of an Inoceramus at Huancavelica that are very close to this species. The form is relatively higher and wider and the concentric costæ are smaller, but as all of the Huancavelica specimens are small, these differences are more marked when compared with larger forms and tend to disappear almost entirely when the specimens are compared with the corresponding stage of *Inoceramus cripsii.*[2] This species has been widely identified in the Upper Cretaceous of North America and Europe and is often considered the same as *Inoceramus balticus* Böhm. The Huancavelica specimens resemble considerably *Inoceramus peruanus* Brüggen from the so-called Emscherian of Huañamba, Peru.[1] They are also not unlike what d'Orbigny called *Astarte dubia.*[2]

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[1] Woods, H., Mon. Cret. Lamell. England, vol. 2, pt. 3, p. 99, pl. 13, figs. 4-6; pl. 14, fig. 1., 1906.

[2] For bibliography and fully illustrated account of this species see Woods, H., Cret. Lamelibranchiata of England, vol. 2, p. 273, pl. 48, figs. 2, 3, tf. 33-35, 1911.

Inoceramus Lissoni Berry, n. sp.

PLATE VIII—Fig. 2.

This may be a young form, if not it is a very small species. There are two specimens of each valve in the collection from Huancavelica and no larger ones, which suggests that it may be a distinct species, although it might represent the young of some form similar to *Inoceramus labiatus* (Schlotheim).

The valves are subequal, inequilateral, moderately inflated; height about the same as the length; umbones prominent, curving in front; hinge line relatively long, at slightly more than a right angle with the anterior margin, which is somewhat flattened. Concentric folds regular, not prominent. Posterior ear well developed.

Dimensions: Length 2 cm., height 2 cm., width about 6 mm. Named in honor of our friend Carlos I. Lisson of Lima, who has done so much to advance the paleontology of his native country.

Among previously described forms the present species is somewhat like *Inoceramus Lamarcki* var. *apicalis* described by Woods[3] from the Upper Cretaceous of England.

Family OSTREIDÆ

Genus OSTREA Lamarck

Ostrea Boucheroni Coquand[4]

Ostrea Boucheroni Coquand, Géol. Pal. Constantine, p. 227, pl. 19, figs. 7-13, 1862; Mon. Ostrea Terr. Crét., p. 85, pl. 31, figs. 1-3; pl. 37, figs. 1-16; pl. 38, fig. 20, 1869.

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[1] Brüggen, H., Neues Jahrb., Beil. Bd. 30, p. 751, pl. 25, fig. 6, 1910.

[2] d'Orbigny, A., Voy. dans l'Amerique Meridionale, tome 8, pl 6, figs. 12, 13, 1847.

[3] Woods, H., Cret. Lamellibranchiata of England, vol. 2, p. 319, pl. 53, fig. 4, 1912.

[4] Only representative citations are given.

Woods, Cret. Lamell. of England, p. 391, pl. 60, figs. 1-15, 1913.

Ostrea Rouvillei Schlagintweit (not Coquand), Neues Jahrb., Beil. Bd. 33, p. 105, pl. 6, fig. 2, 1911.

The question of the specific identity of small smooth ostreid shells is always a baffling one and the present species might readily be confused with the variable and oft recorded *Ostrea incurva* Nilsson of Europe. There is also considerable resemblance to the smaller forms of the North American *Ostrea glabra* Meek. Attention should also be called to the small shells which White referred[1] to his species *Aucella braziliensis* from the Cretaceous of the Province of Sergipe, Brazil. The form which Schlagintweit recorded from the "Cenomanian" of the Pampa de Culebra as *Ostrea Rouvillei* Coquand should doubtless be referred to this species.

The species may, of course, be distinct from the Old World form, but if so, it differs so slightly that differential characters are not discernible in the present material.

Genus EXOGYRA Say

Exogyra pseudo-africana Choffat

Ostrea pseudo-africana Choffat, Rec. Et. Pal. Fauna Crét. du Portugal, vol. 1, p. 38, pl. 4, figs. 1-4, 1886.

Several more or less exfoliated specimens of a large and massive lamellose Exogyra from Huancavelica almost certainly represent this species. Choffat considers it to be related to *Exogyra olisiponensis* Sharpe, and in a recent publication[2] he points out its very obvious resemblance to *Exogyra ponderosa* Roemer. *Exogyra pseudo-africana* gives its name to a lower Cenomanian zone in Portugal and Algiers. Our material from Huancavelica is too incomplete for pointing out the specific differences between it and *Exogyra ponderosa.*

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[1] White, C. A. Archiv. Mus. Nac. Rio de Janeiro, vol. 7, p. 56 (part), pl. 3, figs. 14-18 (not figs. 11-13), 1888.

[2] Choffat, P., Com. Commissao Serv. Geol. Portugal, tom xi, p. 179, 1917.

There is a close similarly between *Exogyra ponderosa* and an Exogyra from several localities in the Cretaceous of Peru which is labelled *Exogyra polygona* von Buch in the collections at Lima. This material was much better than that we obtained at Huancavelica and probably represents *Exogyra pseudo-africana* Choffat, although in the absence of the material for comparison, it would be unwise to more than call attention to this probability.

Exogyra polygona von Buch is recordea from the following localities in Peru, which have been considered Cenomanian in age:

Balzas, Province of Chachapoyas, Department of Amazonas;

Near Bambamarca, Province of Hualgayoc, Department of Cajamarca;

Huanco, Province of Calendín, Department of Cajamarca;

Combayo, Pampaulebra, and Palloc, Province of Cajamarca, Department of Cajamarca;

Huayamba, Province of Cajabamba, Department of Cajamarca;

Chota, Provine of Chota, Department of Cajamarca;

Oroya, Department of Junín.

Exogyra olisiponensis Sharpe var *duplex* Steinmann was described by Paulcke from the Department of Cajamarca, Peru.[1] This is not the same as the specimens here identified as *Ezogyra pseudo-africana,* but according to Schlagintweit[2] this variety is not a good one and he unites it with *Exogyra polygona* von Buch and refers both to *Exogyra olisiponensis* Sharpe.

Exogyra maroimensis (White)

PLATE VIII—Fig. 6, 7.

Ostrea maroimensis White, Archiv Mus. Nac. Rio de Janeiro, vol. 7, p. 27, pl. 2, figs. 13, 14, 1888.

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[1] Paulcke, W., Neues Jahrb., Beil. Bd. 17, p. 269, pl. 15, figs. 7, 8, 1903.

[2] Schlagintweit, O. Idem, Bd. 33, p. 109, 1911.

Three specimens from Huancavelica which appear to be identical with the form described under the above name by White from the Cretaceous of the Province of Sergipe, Brazil. The cover valve is thick, flat, and nearly smooth, and the form appears to belong to Exogyra rather than Ostrea. Nothing similar appears to have been heretofore described from the Peruvian Cretaceous. It is somewhat like the small subangular forms of the common North American *Ostrea lugubris* Conrad, but is obviously distinct from that species.

Exogyra minos Coquand (?)

Ostrea minos Coquand, Mon. du genre Ostrea Terr Crét. p. 183, pl. 64, figs. 1-3; pl. 73, figs. 4-8; pl. 74, figs. 14, 15, 1869.

Exogyra minos Sommermeier, Neues Jahrb., Beil. Bd. 36, p. 390, pl. 14, figs. 2, 3, 1913.

Two specimens of what Sommermeier identified as this European Lower Cretaceous species were collected at Huancavelica. Sommermeier's material came from Huaninga, Department of Ancachs, and he considers its age as Aptian. It is doubtful if either of these represent Coquand's species. The beaks appear to be much straighter for one thing Exogyras at best do not offer well marked specific characters and when the material is fragmentary it might perhaps be best to discard it altogether. At the same time the Huancavelica specimens do show the presence at this horizon of a mediumly large sized, very thick shelled, markedly costate species of Exogyra.

Exogyra Reissi Paulcke

Exogyra Reissi Paulcke, Neues Jahrb. Beil. Bd., 17, p. 271, pl. 15, figs. 5, 6, 1903.

Represented by a single specimen from Huancavelica. Described from material collected by Reiss from Ursula near Cajamarca, Department of Cajamarca, from beds considered to be of Cenomanian age. It differs from *Exogyra columba* Lamarck recorded by Schlagintweit from a similar horizon in Peru (Cuesta de Huanyamba) in lácking the spiral umbos of that species. This is probably not a new form but more likely identical with the widespread *Exogyra* *conica* (Sowerby)[1] to which should probably also be referred the *Exogyra arduennensis* (d'Orbigny) of northern Africa, with which Paulcke compares his *Exogyra Reissi*.

Under the name of *Exogyra* cf. *conica* Sowerby, Douglas records[2] what is probably this same form from the socalled Cenomanian along the Oroya Railroad in central Peru.

Family PECTINIDÆ

Genus PECTEN Müller

Pecten æquicostatus Lamarck (?)

PLATE VIII—Figs 8-10.

Pecten versicostatus Lamarck, Anim. sans Vert., vol. 6, p. 181, 1819.

Goldfuss, Petref. Germaniæ, vol. 2, p. 54, pl. 92, fig. 6, 1833.

Choffat, Faune Cret Portugal, vol. 1m ser. 4, p. 152, pl. 3, fig. 10, 1902.

Woods, Cret. Lamell, England, vol. 1. p. 208, pl. 40, figs. 8, 9, 1903.

Schlagintweit, Neues, Jahrb., Beil. Bd., 33, p. 121, 1911.

The numerous specimens of an equicostate Pecten from Huancavelica are referred to this species with considerable hesitation. They are exceedingly difficult to distinguish from the flat valves of *Pecten quinquecostata,* and are less gibbous than most figures of *Pecten æquicostatus.* The shells are somewhat inequilateral, the ears small, the ribs numerous and smooth. They were compared with various species of Lima, but appear to represent a Pecten and to be not far removed from this variable, widespread, and perhaps composite, species. It was described originally from the type locality of the Cenomanian, Le Mans, France, and has been recorded from a great many localities. Neumann recorded it from what he considered Cenomanian at Cachache, Province of Cajabamba and Mirco near San Marcos, Province of Chota, both in the Department of Cajamarca, Peru. Although he did not describe his specimens very fully and they were unfigured, his determination has influenced the decision to refer the Huancavelica forms to this species tentatively.

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[1] For an illustrated account of this species see Woods, H., Cret. Lamell. of England, vol. 2, p. 407, text figs. 215-242, 1913.

[2] Douglas, J. A., Quart. Jour. Geol. Soc., vol. 77, p. 272, 1921.

Pecten quinquecostatus Sowerby

PLATE IX—Fig. .1, 2.

Pecten quinquecostatus Sowerby, Min. Conch., vol. 1, p. 122, pl. 56, figs. 4-8, 1814.

Pecten versicostatus Lamarck, Anim. sans Vetr., vol. 6, p. 181, 1819.

Pecten quinquecostatus Brongniart, Geol. des Env. Paris, pl. 4, fig. 1, 1822.

Pecten quinquecostatus Nilsson, Petrif. Suecana, p. 19, tab. 9, fig. 8; tab. 10, fig. 7, 1827.

Pecten quinquecostatus Morton, Amer. Jour. Sci., 1st ser., vol. 17, p. 285; vol. 18, pl. 3, fig. 5, 1830.

Pecten versicostatus Deshayes, Enc. Méth., t. 3, p. 727, 1832.

Pecten quinquecostatus Morton, Syn. Org. Rem. Cret. Grooup U. S., p. 57, pl. 19, fig. 1, 1834.

Pecten quinquecostatus Goldfuss, Petrif. Germ., t. 93, fig. 1, 1836.

Pecten quinquecostatus Bronn., Lethaca Geogn., Bd. 2, pp. 678-680 taf. 30, fig. 17, 1838.

Janira quinquecostata d'Orbigny, Paléont. Franc. Terr. Crét., vol. 3, p. 632, pl. 444, figs. 1-5, 1846.

Janira mortoni d'Orbigny, Prod. Paléont. Strat., vol. 2, p. 253, 1850.

Pecten quadricostatus var. Roemer, Kreide. von. Texas, p. 64, pl. 8, figs. 4a-4c, 1852.

Pecten quadricostatus Shumard, Marcy Expl. Red River, Louisiana, p. 178, pl. 2, figs. 2a, 2b; pl. 3, fig. 6, 1854.

Neithea mortoni Gabb, Proc. Acad. Nat Sci., Phila., for 1861, p. 365, 1862.

Neithea mortoni Meek, Check List Inv. Fossils N. A., Cret. and Jur., p. 7, 1864.

Neithea mortoni Conrad, Cook's Geol. of New Jersey, p. 725, 1868.

Pecten quadricostatus Credner, Zeitsch. deutsch. geol. Gesell. Bd. 22, p. 232, 1870.

Vola quinquccostata Stoliczka, Mem. Geol. Survey India, Palaeont. Indica. Cret. Faunas of Southern India, vol. 3, p. 437, pl. 31, figs. 1-6; pl. 38, figs 4-9, 1871

Neithea quinquecostata Gabb, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. 8, 1877.

Neithea quinquecostata Whitfield, Mon.. U. S. Geol. Survey, vol.

9, p. 56, pl. 8, figs. 12-14, 1885.

Vola quinquecostata Paulcke, Neues Jahrb., Beil. Bd. 17, p. 276, 1903.

Dueñas, Bol. Cuerpo Ing. d. Minas del Peru, No. 62, p. 154, 1908.

Vola quadricostata White, Archiv.Mus. Nac. Rio de Janeiro, vol. 7, p. 37, pl. 4, figs. 1, 2, 1888.

Neithea quinquecostata Weller, Geol. Survey of New Jersey, Pal., vol. 4, p. 481, pl. 51, figs. 7-12.

Vola quinquecostata Böse, Bol. Inst. Geol. Mexico, p. 99, pl. 15, figs. 19, 20, 1910.

Pecten quinquecostatus Gardner, Md. Geol. Survey, Upper Cret., p. 596, pl. 34, fig. 10, 1916.

The identity between the American and European forms referred to this loosely conceived species, or in fact, the variety of forms so identified from a single region, has been a controverted one since the day of d'Orbigny, and doubtless will continue so until some one with ample material undertakes a revision of the whole question.

It is common at Huancavelica and one specimen in the possession of Señor Gastelumendi measured 10.5 cm. in height and 10.25 cm. in width. Views of average sized specimens of both the convex and flat valves are shown on the accompanying plate.

If one may judge from the localities cited by Lisson[1] the species is exceedingly common in the Andean Cretaceous. It has been recorded from the following localities:

Calluan, Department Cajamarca;
Colpa, Department Cajamarca;
La Tahona, Department Cajamarca;
Pampa Culebra, Department Cajamarca;
Huayllabamba, Department Cajamarca;
Cuesta de Calendín, Department Cajamarca;
Sillipata, Department Lima;
Hacienda Macanga, Department Libertad;
Quebrada de Huari, Department Junín;
La Lucha, Department Junín;
Sincamachay, Department Junín;

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[1] Lisson, C. I., Edad de los Fósiles Peruanos, 1917.

Pomaconcha, Department Junín;
Lloellapampa, Department Junín.

These have been considered Aptian, Paulcke calls their age Santonian. It is found also in the Upper Cretaceous of England, France, Germany, Tunis, Algiers, India, and Brazil.

Pecten sp.

PLATE X—Fig. 2.

A small flat coarsely equicostate large-eared pecten is represented in the Huancavelica collection by the single specimen figured. Its affinities cannot be determined.

Family ANOMIIDÆ

Genus ANOMIA (Linné) Müller

Anomia peruana Gabb.

PLATE X—Fig. 6.

Anomia peruana Gabb, Jour. Acad. Nat. Sci., Phila. 2d ser., vol. 8, p. 295, pl. 42, fig. 6, 1877.

Anomia cf. *laevigata* Sowerby, Schlagintweit, Neues. Jahrb., Beil. Bd. 33, p. 93, pl. 5, figs. 4-6, 1911.

The small Anomia represented at Huancavelica by the single valve figured shows a perfectly symmetrical shell with surface marked by concentric growth lines and very fine radial lines. The shell substance is preserved, which is unusual in the Peruvian Cretaceous, and is distinctly that of this genus. The concentric markings are more prominent in the earlier half of the shell and are low folds rather than lines; and the radial ornamentation in the younger half. It is identified with some uncertainty as the form to which Gabb gave the above name. This was very poorly described and figured by Gabb and was based upon material collected by Raimondi near Chachapoyas, Department of Amazonas. Judging more from the name suggested rather than the illustrations, this is the same form that Schlagintweit recorded from La Victoria near Yauli, Department of Junín, from a horizon which he considered Vraconnian. The species, although probably distinct, is very similar to *Anomia lævigata* Sowerby,[1] a very common Lower Cretaceous form of the Old World

Anomia sp. has been recorded from Pachacayo, Department of Junin, and *Anomia* cf. *pseudoradiata* d'Orbigny has been recorded from Calluan and Cachache in the Department of Cajamarca, from beds referred respectively to the "Albian" and "Aptian."

Order ANOMALODESMACEA

Family PHOLADOMYIDÆ

Genus PHOLADOMYA Sowerby

Pholadomya ellipticaformis Berry sp. nov.

PLATE X—Fig. 7-9.

Pholadomya cf. *nodulifera* Münster, Sommermeier, Neues Jahrb., Beil. Bd. 36, p. 376, pl. 14, fig. 15, 1913.

This is suspected to be the same as the form which Sommermeier identified from several localities in Peru as *Pholadomya* cf. *nodulifera* Münster. The only obvious resemblance to Münster's type is in the surface ornamentation. The shell itself in the European material being much shorter, higher, and wider. For example Münster's original figure has the following dimensions:

Length 9.2 m., Height 6.8 m., Width 5.2 cm.

The figured specimen from Huancavelica has the following dimensions:

Length 9 cm., Height 4.3 cm., Width 3.4 cm.

The latter is a cast and the surface features are inferred from a smaller broken specimen which may not be the same but represent a second species from Huancavelica. This is regarded as doubtful, however, since as far as the two can be compared they represent the same species. If the South American form is to be regarded as identical with one from the European Cretaceous it is much closer to *Pholadomya elliptica* Münster which is found from the Cenomanian to

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[1] For an account of this species see Woods, H., Cret. Lamell. England, vol. 1, p. 29, pl. 5, figs. 6-9, 1899.

Senonian in France, Germany, and Russia. Specific identity between the two is regarded as most unlikely, and the Peruvian form is considered as new. It may be incompletely characterized as follows:

Shell subelliptical in lateral outline; cordate and moderately ventricose from in front; the two valves in the latter view slightly inequilateral, but this may be due to deformation. Hinge line straight, about one-half the length of the shell. Anterior margins evenly rounded from the cardinal extremity to the basal margins. Basal margins gently and evenly convex in back as in front. Posterior margins evenly rounded. Beaks large, broad, not incurved, moderately elevated, situated one-third of the distance from the anterior margin of the valves. Valves most prominent about midway in their height; from this point the surface curves regularly to the anterior margins, more abruptly to the cardinal margins, and more gently to the posterior margins: the latter are gaping for its entire height, and more so than the anterior in both height and width. The inflected cardinal margins immediately behind the beaks form a distinct, short and broadly lanceolate cardinal area. Surface of the valves (characters based on a smaller specimen which may not be the same) with prominent radial costæ. There are about 12 of these in the small specimen, but they were probably much more numerous in adult shells. These costæ are crossed by prominent growth lines, resulting in nodular-like knots where they cross the costæ. The costæ are rounded and separated by from 2 to 3 times their width of flattened intercostal bands.

This species resembles both *Pholadomya nodulifera* and *Pholadomya elliptica* of Europe, both of which range from the Cenomanian to the Senonian. Münster's type material of both came from the greensand of Blankenburg (Harz). The species is not uncommon at Huancavelica, and, if it is correct to consider it the same as what Sommermeier called *Pholadomya* cf. *nodulifera* Münster, it has a wide range and was rather common in the Andean Cretaceous. Sommermeier had material from the following localities: Cochamarca, 7 km. northwest of San Marcos, Cuesta de Huanyamba, west of Celedin, both in the Department of Cajamarca; Curgos, Department of Libertad; West Sihuas, Department Ancash; and Ancahuaina, near Morococha, Department of Junin. He considered these as Albian in age.

Neumann has imperfectly described and figured *Pholadomya quinuana*[1] from La Quinua, Department of Cajamarca, from beds of supposed Emscherian age. This is a much shorter, higher, and more ventricose form, with more numerous and more closely spaced costæ. This author also records, without illustrations, *Pholadomya* cf. *connectans* Forbes and *Pholadomya* sp. aff. *P. Molli* Coquand from beds of similar age in middle Peru.

Order TELEODESMACEA

Family CRASSATELLITIDÆ

Genus CRASSATELLITES Krüger

Crassatellites caudata Gabb

Crassatellites caudata Gabb, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. 8, p. 287, pl. 40, fig. 18, 1877.

Gerhadt, Neues, Jahrb. Beil. Bd. 11, p. 107, pl. 2, figs. 11a, 11b, 1898.

Cyrene Dürfeldi Steinmann, Idem, 9, p. 144, pl. 8, figs. 6, 7, 1895.

This cast from Huancavelica is a typical Crassatellites and is probably identical with the material collected by Raimondi and described by Gabb from the so-called Albian of Pariatambo and Cerro Ventanillo. Steinmann, who described the Dürfeld collection from that region, referred identical material to Cyrene, as a new species, a mistake which was corrected in Gerhardt's work.

The only other Crassatellites found recorded from the Peruvian Cretaceous are *Crassatella* (*Plionema*) *conservata* Gerhardt[2] from Pariatambo, a similarly sized but shorter, rounder and quite distinct form; and *Crassatella* (*Pachythærus*) *myophoroides*;[1] another one of Steinmann's Cyrenas from Pariatambo, which is nothing like this species. Both are from beds that Gabb called Liassic, but that are commonly considered Albian, and are certainly Cretaceous. There is some resemblance between *Crassatellites caudata* Gabb and *Crassatella Zitteliana* Stoliczka of the Arrialoor group of southern India, but the former is much more closely allied to *Crassatella Picteli* Coquand[2] of the Cenomanian of Constantine in Algiers.

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[1] Neumann, E., Neues Jahrb., Beil. Bd. 24, p. 115, pl. 5, fig. 2, 1907.

[2] Gerhardt, K., Neues Jahrb., Beil. Bd. 11, p. 106, pl. 2, figs. 10-10c, 1898.

Family ASTARTIDÆ

Genus ASTARTE Sowerby

Astarte sp.

PLATE IX—Fig. 2.

A single cast from Huancavelica. The triangular form, elevated beaks, prominent muscle scars and concentric ribs confirm the reference to this genus. In the absence of more representative material it is futile to attempt specific comparisons, although it may be said that the present form appears to be different from any of the casts described by Steinmann and his students from the Cretaceous of Peru.

Family CARDITIDÆ

Genus CARDITA (Bruguière) Lamarck

Cardita Doumeti Thomas and Peron

Cardita Doumeti Thomas and Peron, Desc. invert. foss. crét. Tunisie, p. 267, pl. 23, 1891.

Schlagintweit, Neues Jahrb., Beil. Bd. 33, p. 123, pl. 6, fig. 6, 1911.

This species, which was described originally from the Cenomanian of Algiers and Tunis, was recorded by Schlagintweit from the supposed Cenomanian of Mirco near San Marcos, Province of Chota, Department of Cajamarca, Peru. A perfectly typical specimen was collected at Huancavelica. It is certainly very closely allied to, even if subsequent study of more abundant material should show that it is specifically distinct from the African form.

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[1] Idem. p. 109, pl. 2, fig. 12.

[2] Coquand, H., Géol. & Paléont. Région sud Prov. Constantine, pl. 13, figs. 10, 11, 1862.

Cardita huancavelicensis Berry n. sp.

PLATE X.—Fig. 3.

Shell small, inflated, subelliptical in outline, very inequilateral, with prosogyrate beaks. Anterior margin evenly rounded. Posterior margin more narrowly rounded. Surface ornamented by about 14 concentric rounded costæ which increase in prominence from the umbo to the margin; these are crossed by less well marked radial ridges, which result in the concentric costæ being more prominent where they are crossed by the radial ridges, the latter being practically obsolete in the sharp depressions between the concentric lamellæ. There are about 18 of these faint radial ridges behind the abruptly rounded anterior slope. Features of the cardinal region or hinge not visible.

Length 1.6 cm., height 8 mm., width 1.2 cm.

This is described as a new species. Nothing similar to it is known in the Cretaceous faunas of southern India, but there are several species in the north African Cenomanian that are somewhat similar.

This is probably the form which Schlagintweit recorded[1] as *Cardita* sp. from the Pampa de Culebra of Peru, from beds of supposed Cenomanian age, and which he compared with the north African species *Cardita Fourgemoli* Coquand and *Cardita Benquei* Coquand.

Family LUCINIDÆ

Genus LUCINA

Lucina sp.

PLATE X—Fig. 4.

These small shells do not show any features of the hinge but appear to belong to the genus Lucina. They are not unlike *Lucina porrecta* Gerhardt[2] of the supposed Lower Cretaceous of Colombia.

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[1] Schlagintweit, O., Neues Jahrt., Beil. Bd. 33, p. 123, 1911.

[2] Gerhardt, K. Neues Jahrb., Beil. Bd. 11, p. 162, pl. 3, fig. 13, 1898.

Family CYPRINIDÆ

Genus CYPRINA Lamarck[1]

Cyprina (?) sp.

PLATE IX—Fig. 4.

Based on casts, not certainly determinable, but representing either this or the genus Cyprimeria Conrad. It is not unlike the North American Upper Cretaceous *Cyprina ovata* Meek.

An unnamed Cyprina is recorded by Brüggen[2] from the so-called Emscherian of Otuzco, Department of Cajamarca, but as it is not figured it is impossible to say whether or not it is identical with the Huancavelica form. Sommermeier recorded[3] an unnamed Cyprina from the so-called Albian of Cajamarca, but as he compared it with Woods' figures[4] of the European *Cyprina angulata* Sowerby, it is evidently different from the Huancavelica species, and represents a larger, relatively shorter and higher shell, with a pronounced posterior shoulder.

Other specimens recorded from the same locality by Sommermeier (op. cit.) and compared to the European *Cyprina protensa* Woods[5] may be the same as those from Huancavelica. A still different and very doubtful form from the so-called Santonian of Charata Pass, Department of Junín, is recorded by Neumann.[6]

Family CARDIIDÆ

Genus CARDIUM Linné

Cardium pulchrum Brüggen

PLATE X—Fig 1.

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[1] The genus Cyprina is antedated by Arctica Schum. 1817 and Dall has therefore proposed the name Pleurophoridæ for the family.

[2] Bruggen, H., Neues Jahrb., Beil. Bd. 30, p. 756, 1910.

[3] Sommermeier, L., Neues Jahrb., Beil. Bd. 36, p. 385, 1913.

[4] Woods, H., Cret. Lamell England, vol. 2, p. 141, pl. 22, figs. 1-4, 1907.

[5] Woods, H., Idem, p. 137, tf. 20, 21, pl. 21, figs. 4-7.

[6] Neumann, R., Neues Jahrb., Beil. Bd. 24, p. 113, pl. 4, fig. 3.

Cardium pulchrum Brüggen, Neues Jahrb., Beil. Bd. 30, p. 755, pl. 25, fig. 8, 1910.

Two minimum sized specimens and a single somewhat indefinite larger one of this species are contained in the Huancavelica collection. All are casts and the smallest one, that figured, is the only one even partially showing the ornamentation. The species, according to Brüggen, reaches a height of 4 cm., a length of 3 cm., and a width of 2.5 cm. It is recorded from Huaillahuaran near Parobamba, Department of Huánuco; Pastos de Lachoj, Department of Huánuco; La Quinua, Department of Cajamarca; Cuesta de Huanyamba (Huañambra), Department of Cajamarca.

Family TELLINIDÆ

Genus TELLINA (Linné) Lamarck

Tellina scitulina Stoliczka

Tellina scitulina Stoliczka, Pal. Indica, Cret. Fauna Southern India, vol. 3, p. 126, pl. 4, figs. 10-13, 1871.

Neumann, Neues, Jahrb., Beil. Bd. 24, p. 114, pl. 3, figs. 4, 4a, 1907.

A single specimen of this species from Huancavelica. It was described by Stoliczka from the Arriloor group of India and has been previously recorded from Peru from the so-called Campanian of La Quinua and the so-called Santonian of Charata Pass, Department of Junín. There may well be some doubt regarding specific identity between Indian and South American Cretaceous occurrences, but the Huancavelica material is certainly identical with what Neumann recorded as *Tellina scitulina* Stoliczka.

Tellina inconspicua (Sowerby) Stoliczka

Psammobia ? inconspicua Sowerby, Trans. Geol. Soc. Lond., vol. 7, p. 142, pl. 15, fig. 18, 1846.

? *Tellina Grangerei* d'Orbigny, Voy. Astrolabe, Palaeont. pl. 5, figs. 8-10, 1847.

Tellina inconspicua Stoliczka, Pal. Indica, Cret. Fauna Southern India, vol. 3, p. 129, pl. 4, figs. 6-8, 1871.

Tellina sp. Brüggen, Neues. Jahrb. Beil. Bd. 30, p. 760, 1910.

There are two specimens in the Huancavelica collection, one of which shows the characteristic surface ornamentation, which cannot be separated from this species as recorded by Stoliczka from the Trichinopoly group of southern India. It is a larger form than the other two forms of Tellina found at Huancavelica, and has a much more equilateral shell than the second of these (Tellina sp.).

Tellina sp.

PLATE X—Fig. 5.

This is identical with *Tellina subscitula* Meek[1] of the North American Upper Cretaceous (Mentor=Cenomanian) except that the pallial sinus is considerable smaller. It is correspondingly less high, and more inequilateral than *Tellina scitulina* Stoliczka which also occurs at Huancavelica; and much smaller, more elongate, less equilateral and lacking the concentric ornamentation of *Tellina inconspicua* (Sowerby) Stoliczka which is also found at Huancavelica. Neumann has recorded[2] *Tellina* cf. *refanensis* Coquand, a North African Emscherian species, from the so-called Campanian of La Quinua, Peru, that is somewhat similar to the present form.

Class GASTROPODA

Superfamily PTERIOGLOSSA

Family TURRITELLIDÆ

Genus TURRITELLA Lamarck

Turritella vibrayeana d'Orbigny (?)

Turritella vibrayeana d'Orbigny, Pal. Franc. Crét., t. 2, p. 37, pl. 151, figs. 10-12, 1843.

Böse, Bol. Inst. Geol. Mex. No. 25, p. 145, pl. 30, fig. 10; pl. 31, fig. 6, 1910.

Schlagintweit, Neues Jahrb., Beil Bd. 33, p. 96, 1911.

Turritella Raimondi Gabb, Jour. Acad. Nat. Sci., Phila., 2d. ser., p. 279, pl. 40, fig. 2, 1881.

There are three very poorly preserved fragments from Huancavelica showing parts of the surface ornamentation that are tentatively identified as this form. They may or may not be identical with d'Orbigny's types, which were from the Vraconnian of France, but they are probably identical with the Peruvian material of Gabb and Schlagintweit. This came from Pariatambo, Chaquil, and La Victoria near Yauli, the last in the Department of Junín.

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[1] Meek, F. B., U. S. Geol. Surv. Terr., vol. 9, p. 195, pl. 2, figs. 11-11b, 1876.

[2] Neumann, R., Neues Jahrb., Beil. Bd. 24, p. 114, 1907.

Turritella sp.

PLATE IX—Fig. 5.

The single specimen figured is somewhat suggestive of the common Mesozoic genus Nerinea Defranc, with which it is associated, but the aperture is oval and both the columella and lips are smooth and without the strong folds of that genus, so that it is obviously referable to the genus Turritella. It probably is new, at least nothing like it was found from the Cretaceous, although it is not unlike several Tertiary species. In the absence of more complete material no attempt is made to name or characterize it. The prominent angular shoulder, one-third of the distance below the somewhat impressed suture and the marked wavy transverse growth lines shown in the illustration, will serve to identify it in future collections.

Unidentified species of Turritella are recorded from the following localities in the Peruvian Cretaceous in Lisson's admirable compilation:[1] Carhuaz, Province of Huaras, Department of Ancachs in the so-called Aptian; and La Quinua, Province of Pasco, Department of Junín; Huallaga, Province and Department of Huánuco; Otuzco and Hacienda Yanacancha in the Province and Department of Cajamarca from the so-called Emscherian.

Family NERINEIDÆ

Genus NERINEA Defrance

Nerinea cf. *espaillaciana* d'Orbigny

There are many poorly preserved specimens at Huancavelica that appear to represent a species very similar to *Nerinea espaillaciana* d'Orbigny,[2] a European form from the Rotomagian (Cenomanian). They are also not unlike *Nerinea incavata* Bronnas described by Stoliczka from the Ootatoor group of southern India.[1] The genus is well represented in the Cretaceous of Mexico, and there are several species in the Comanchean Cretaceous of Texas.

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[1] Edad de los Fósiles Peruanos, 1917.

[2] d'Orbigny, A., Pal. Franc. Cret. tome 2, p. 99, pl. 164, fig. 2, 1842.

Family NATICIDÆ

Genus NATICA Adams

Natica Gastelumendii Berry n. sp.

PLATE IX—Figs 6, 7.

Shell small, depressed, the cone rapidly expanding with a low pointed spire of but two whorls. Suture impressed. Whorls rounded, without an obvious shoulder. Umbilicus prominent. Surface marked by rather prominent incremental ridges.

Length about 1.87 cm., width about 9 mm. Named in honor of Señor Gastelumendi, our delightful host during our stay at Huancavelica.

This striking tiny form is characterized particularly by its depressed form, almost obsolute spire, and widely flaring cone. The only previously described form that resembles it at all closely is *Natica excavata* Michelin[2] of the French Albian in which the basal part of the whorl is angulated by the immense, conical, nearly straight-sided umbilicus.

Natica singularis Möricke

PLATE IX—Fig. 8.

Natica singularis Moricke, Neues Jahrb., Beil. Bd. 10, p. 96, pl. 7, figs. 12, 13, 1895.

Natica Gervaisi Coquand. Neumann, Idem, Bd. 24, p. 120, pl. 3. figs. 1, 1a, 1907.

Brüggen, Idem, Bd. 30, p. 738, 1910.

This species, based upon not certainly determinable casts, was described from material collected by Steinmann on Quiriquina Island, Chile. With it should be associated the casts that Neumann and Brüggen have referred to the

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[1] Stoliczka, F., Pal. Ind. Cret. Fauna Southern India, vol. 2, p. 183, pl. 14, fig. 2, 1868.

[2] d'Orbigny, A., Pal. Franc. Crét., tome 2, p. 155. pl. 173, figs. 1, 2, 1843.

African Upper Cretaceous species *Natica Gervaisi* Coquand. There are 10 specimens of various sizes in the Huancavelica collection, some of which are twice the size of the specimen figured.

It may also be compared with Gabb's[*] *Prisconatica inconspicua* based on a single cast from the Province of Huamalies.

It has been recorded from the following Peruvian localities: Charata pass, Lucha, Huaillahuaran, Huanyamba, Sta. Clara, La Quinua.

Genus TYLOSTOMA Sharpe

Tylostoma sp.

Fragments of a rather large gastropod shell at Huancavelica, apparently represent the genus Tylostoma. They are too incomplete for characterization or illustration.

Tylostoma sp. was recorded by Sommermeier[1] from the Aptian (?) of Sincamachay, Province of Yauli, Department of Junín: the north African Santonian form *Tylostoma æquiaxis* Coquand has been recorded[2] from several localities in the Departments of Junín and Cajamarca from beds of supposed Albian age; and the North African Turonian form *Tylostoma Cossoni* Thomas and Peron has been recorded[3] from the so-called Emscherian of Otusco in the Province and Department of Cajamarca.

White[4] described 5 species which he referred to this genus from the Upper Cretaceous of Brazil. The genus Prisconatica Gabb from the Peruvian Cretaceous also probably represents this genus.

190, 1888.

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[*] Gabb, W. M., Jour. Acad. Nat. Sci., Phila., 2d ser., vol. 8, p. 278, pl. 39, fig. 8, 1877.

[1] Sommermeier, L., Neues Jahrb., Beil. Bd. 36, p. 373, 1913.

[2] Paulcke, W., Idem, Bd. 17, p. 273, pl. 16, figs. 2-2b, 1903.
Neumann, R., Idem, Bd. 24, p. 118, 1907.

[3] Brüggen, H., Idem, Bd. 30, p. 739, 1910.

[4] White, C. A., Archiv Mus. Nac. Rio de Janeiro, vol. 7, pp. 187-

Family FULGURIDÆ

Genus PYRIFUSUS Conrad

Pyrifusus (*Rhombopsis*) sp.

PLATE IX—Fig. 10.

Two specimens, which are all that were found at Huancavelica, and neither of these complete, is hardly sufficient for the characterization of a new species. They appertain to the genus Pyrifusus of Conrad and apparently to the section of that genus for which Meek proposed the preoccupied name Neptunella, since changed to Rhombopsis by Gardner.[1] They appear to be entirely distinct from previously described forms, and represent a type that, so far as is known, is confined to the Cretaceous.

Superfamily RACHIOGLOSSA

Family VOLUTIDÆ

Genus LIOPEPLUM Dall (?)

Liopeplum (?) sp.

PLATE IX—Fig. 9.

Small, poorly preserved casts from Huancavelica suggest the exclusively Cretaceous genus Liopeplum of Dall.[2]

Class CEPHALOPODA

Order AMMONOIDEA

Family PRIONOTROPIDÆ

Genu SCHLOENBACHIA Neumayr

Schloenbachia sp.

PLATE IX—Fig. 11.

The single poor impression figured is, except for the following species, the only trace of an ammonite in the Huancavelica fauna. It is too poor and fragmentary for identification although clearly a Schloenbachia type, and possibly to be referred to the genus Mortoniceras. Various species of Schloenbachia are recorded from Peru from beds that have been referred to the Albian and Cenomanian, and of Mortoniceras from beds that have been referred to the Albian and

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[1] Gardner, J. A., Md. Geol. Survey, Upper Cret., p. 456, 1916.

[2] Dall, W. H., Trans. Wagner Inst. Phila., vol. 3, pt. 1, p. 73, 1890.

Emscherian. This is the only specimen in the Huancavelica collection that did not come from the same outcrop, having been picked up from loose material near the mouth of the Belén tunnel.

Family COSMOCERATIDÆ

Genus PLACENTICERAS Meek

Placenticeras syrtale (Morton)

Placenticeras syrtale Neumann, Neues Jahrb., Beil. Bd. 24, p. 128, 1907.

A single small specimen of this species was found at Huancavelica. It is probably the same as the material so named by Neumann. The bibliography of this species is not introduced since it is not altogether certain whether it is identical with Alabama and Texas material. The material is not sufficiently good for accurate conclusions on this point. The Alabama material is thought to have come from the Eutaw formation, and that from Texas from the Taylor marl or Austin chalk. The Huancavelica Placenticeras is certainly distinct from *Placenticeras attenuatum* (Gabb) described from Huari, Department of Junín, although Paulcke[1] considers the two to be closely related. Other forms that have been referred to this genus from the Cretaceous of Peru are *Placenteras guadaloupæforme* and *Placenticeras pernodosus.* All are less compressed than *Placenticeras syrtale.* The latter has been recorded from the Santonian of northwestern Africa and Mexico and an identical or closely related form is recorded from southern Europe and another of the supposed Peruvian forms (*P. guadeloupæ*) has been recorded by Stoliczka from southern India. The whole question of the identity and distribution of these forms is in a deplorably unsettled state, and will doubtless remain so, as regards Peru, until much larger collections of better material becomes available, and until the stratigraphic section is better known. Neumann's record was Charata Pass between Oroya and Garma, from beds supposed to be of Santonian age.

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[1] Paulcke, W., Neues, Jahrb., Beil. Bd. 17, p. 280, 1903.

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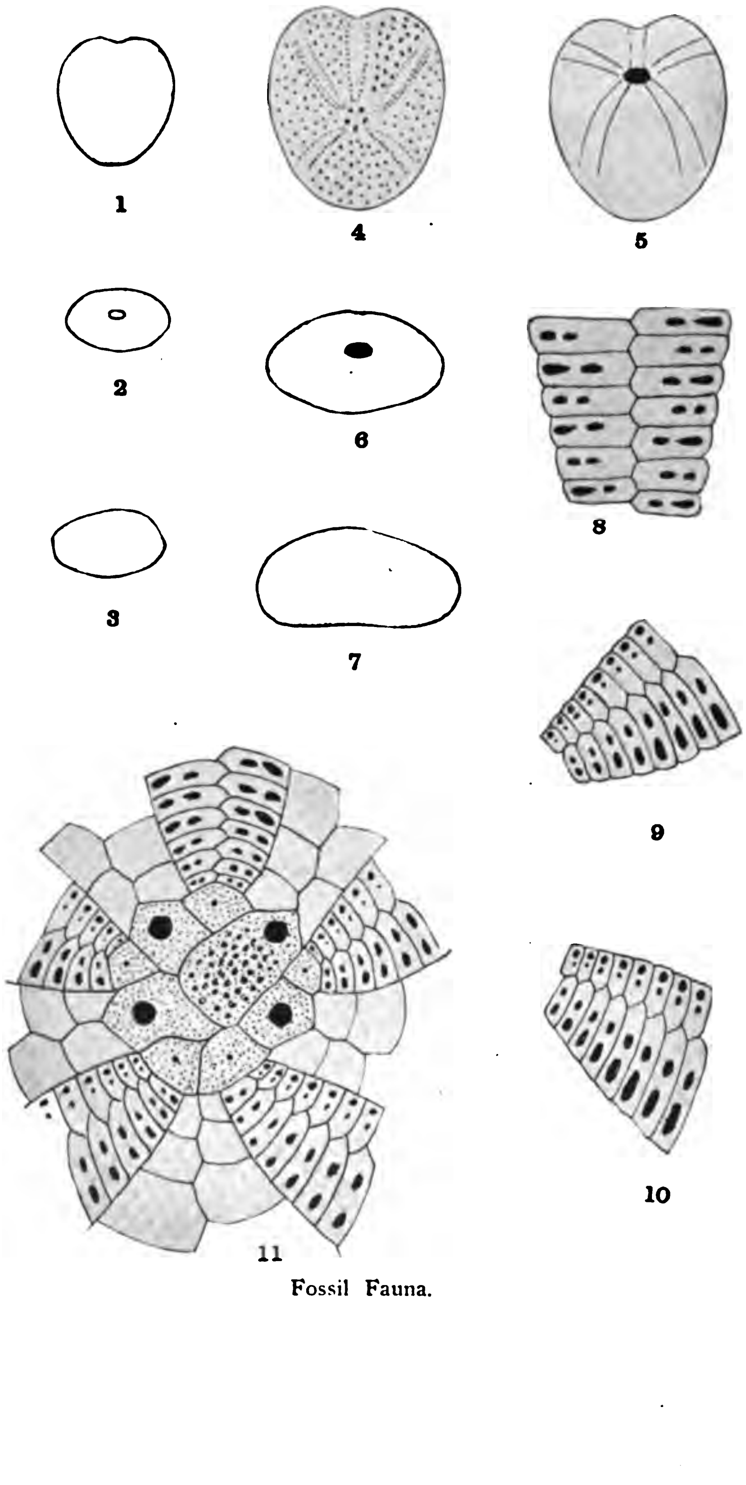
PLATE VI.

Figs. 1-11. Enallaster peruanus Gabb
1. Aboral view of a small specimen
2. Posterior view of same
3. Lateral view of same
4. Aboral view of larger specimen
5. Oral view of same
6. Posterior view of same
7. Lateral view of same
8. Portion of anterior ambulacrum, enlarged
9. Portion of lateral ambulacrum, enlarged
10. Portion of posterior ambulacrum, enlarged
11. Apical system, x 20.



Fossil Fauna.

PLATE VII.

Figs. 1-6. Cyphosoma peruanum Brüggen.
1. Ambital outline of a small specimen
2. Profile of same
3. Ambital outline of a larger specimen
4. Profile of same
5. Arrangement of an ambulacrum at the peristomial border, enlarged
6. Portion of ambulacrum, enlarged

7-12. Botriopygus compressus Gabb
7. Profile of large specimen
8. Aboral view of same
9. Profile of a smaller specimen
10. Oral view of same
11. Pore pairs, enlarged
12. Ambulacrum near the peristome, enlarged

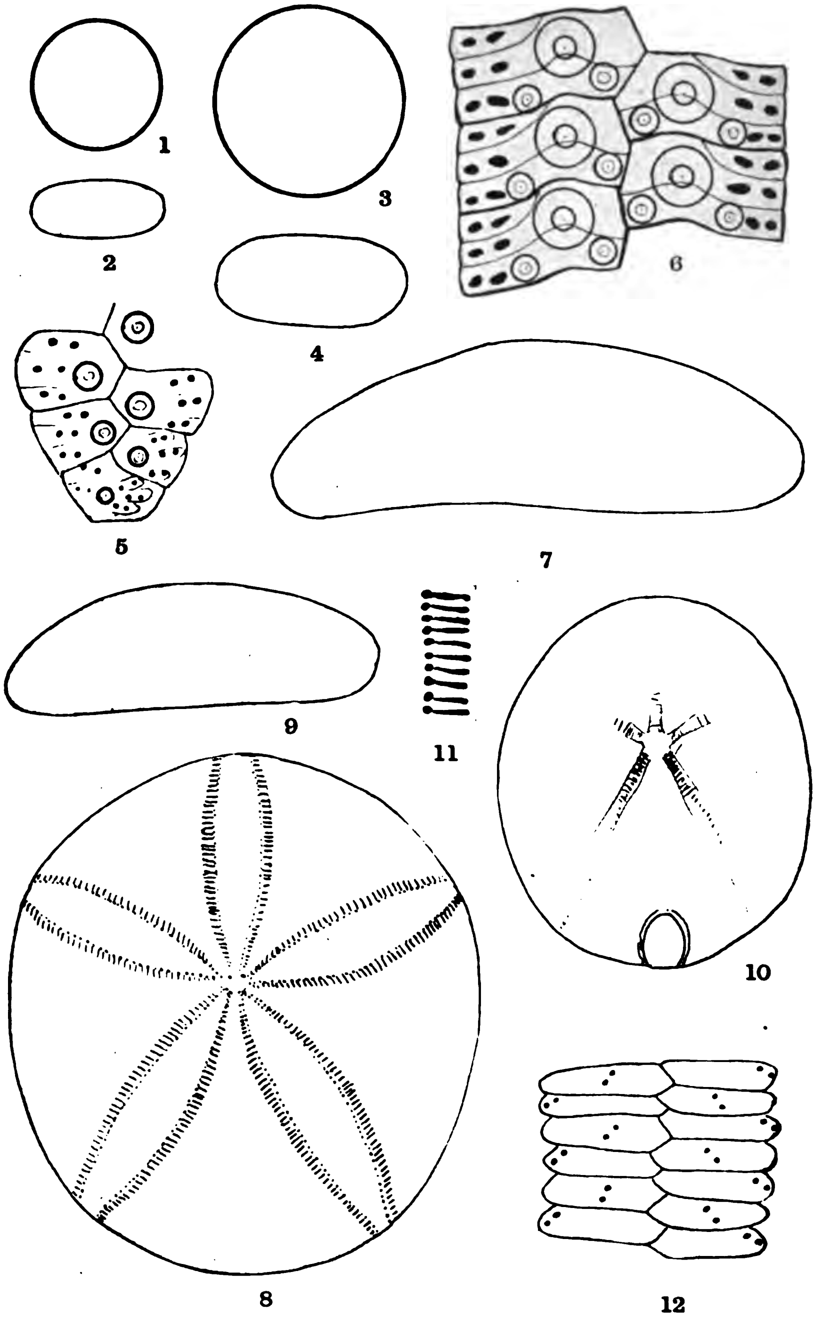


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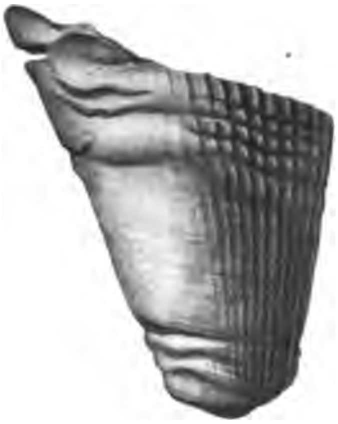
PLATE VIII.

Fig. 1. Pinna decussata Goldfuss (?)
2. Inoceramus Lissoni Berry
3-5. Inoceramus of cripsii Mantell
3. Left valve, 4. From above, 5. Anterior view.
6, 7. Exogyra maroimensis (White)
8-10. Pecten æquicostatus Lamarck (?)
9. Profile of same.



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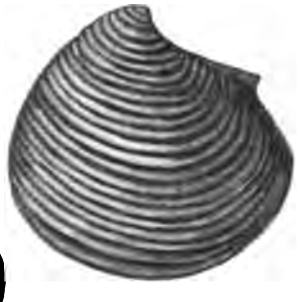

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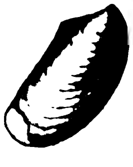

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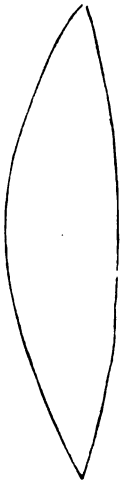

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PLATE IX.

Figs. 1, 2. Pecten quiquecostatus Sowerby
3. Astarte sp.
4. Cyprina (?) sp.
5. Turritella sp.
6, 7. Natica Gastelumendi Berry, x 2
8. Natica singularis Möricke
9. Liopeplum (?) sp., x 2
10. Pyrifusus sp.
11. Schloenbachia sp.

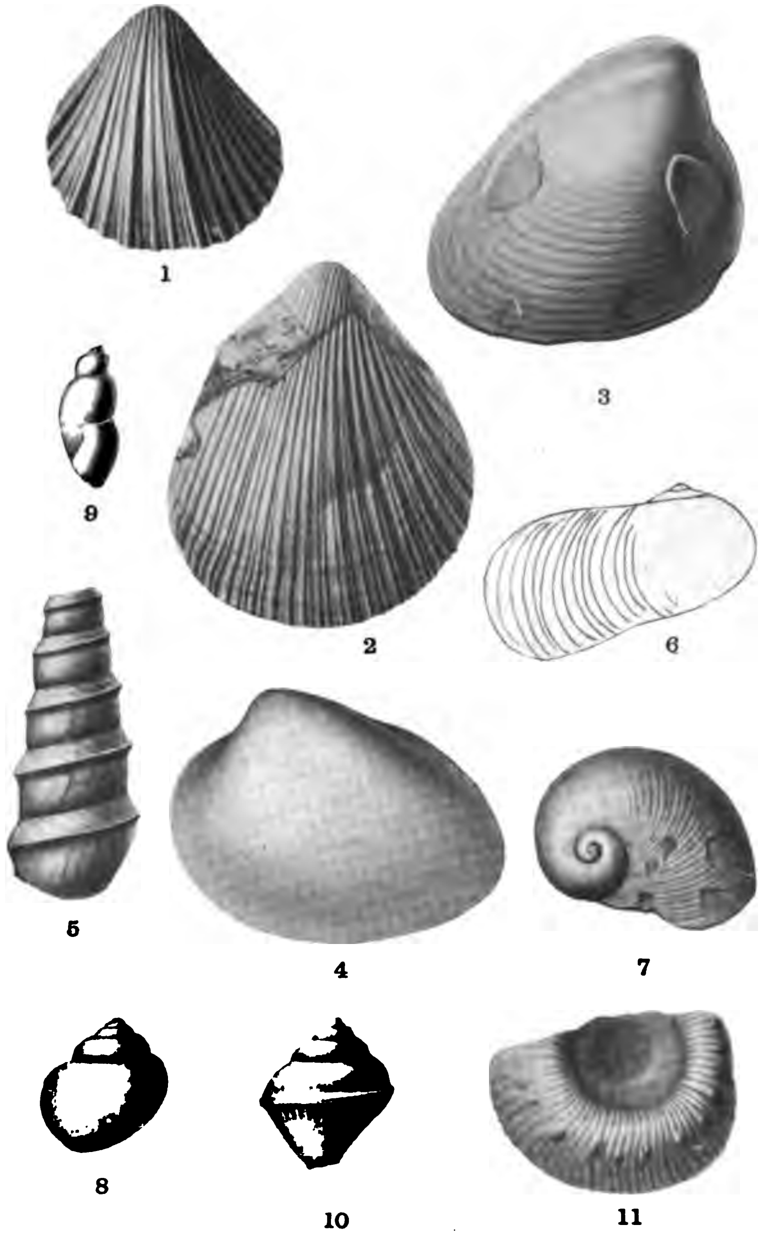

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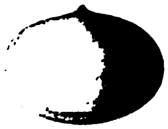
PLATE X.

Fig. 1. Cardium pulchrum Brüggen
2. Pecten sp.
3. Cardita huancavelicensis Berry, x 2
4. Lucina sp., x 1½
5. Tellina sp., x 1½
6. Anomia peruana Gabb, x 2
7-9 Pholadomya ellipticaformis Berry
7. Posterior view
8. Surface ornamentation
9. Cast showing right valve.

1

2

3



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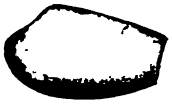

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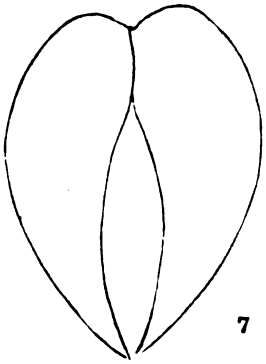

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